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The costs of open learning: a handbook

(with an introduction by Hilary Perraton)

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Hilary Perraton and Thomas Hülsmann

The costs of open learning: a handbook

Introduction

This book is designed to help educational managers who are deciding how to use open and distance learning. It examines the comparative costs of various educational technologies, suggests how we can examine and control costs, and sets out some of the difficulties in doing this. The second half of the book consists of eleven case studies.

The work has been carried out with funding from the European Commission's Socrates programme. We are indebted to them for their support and to the staff of the institutions where we carried out case studies for their interest, cooperation and help.

Open and distance learning has grown dramatically over the last twenty-five years. In many industrialised countries, between six and twelve per cent of all enrolments in higher education are of students studying at a distance. The world now has more than thirty open universities. Perhaps as important, the lines between conventional education and open and distance learning are becoming blurred. Australian universities have started to talk about 'flexible learning'. Within Britain at least half of all universities now have some open-learning programmes. Increasingly, institutions are teaching both through ordinary classrooms and lectures and through open learning. Increasingly, too, students are taking some courses through one mode and some through another. On our doorstep, for example, Anglia Polytechnic University used to teach all its students within its campuses. Today it teaches some on campus, some by franchising courses to other institutions, and some through open learning techniques.

These changes present a double challenge for educational managers. First, managers need to choose the technologies that are most appropriate for the course they are teaching and the students who are following it. Second, they need to look at the cost implications of using open and distance learning.

These intertwined challenges are more complex than at first sight appear. The costs of conventional education are mainly determined by the cost of buildings - from halls of residence to laboratories and classrooms - and the costs of staff. As student numbers increase, so staffing costs increase, although the rise may be tempered by changes in staffing ratios. In open and distance learning, the picture is more complicated with some expenditure on the production of materials, which may be used for any number of students, and some on student support. The cost of preparing materials in different formats will vary: generally, for example, producing materials in print is relatively cheap and in television relatively dear but there may be social and educational reasons for avoiding the cheapest option. The use of computers in education has added a new layer of complexity to the analysis of costs. They make it possible for example, to distribute material cheaply and to allow

students increased interaction with each other and with their tutors, but at the price of demanding investment by the student in a computer and a modem and sometimes of transferring the cost from the teaching institution to the individual student.

Within the project whose results are reported in this book, we have tried to look at some of these complexities. We have done so both by reviewing what is already known about the cost of open and distance learning and by carrying out eleven case studies with colleagues within institutions in Britain, France, Germany, Italy, Norway and Spain. We have used a common framework for examining and analysing costs, looked at the choices of technology that have actually been made by people running educational programmes, and reached some general conclusions to guide decision makers. Table 1.1 sets out the case studies we carried out with summary information on the technologies used.

Our findings are set out in five general chapters in the first half of the book and in the summary case studies which appear as the second part.

Our major findings, on the comparative costs of different technologies and on the factors that affect these, are dealt with in chapter one. In order to put these findings in context, we then move on, in chapter two, to explain the methodology we used and then in chapter three, to discuss the difficulty of interpreting the findings. This makes it possible for us, in chapter four, to produce guidance for the manager on applying the findings and the methodology that have been used and in chapter five to examine some of the issues involved in justifying decisions that follow.

The findings are based on quite different case studies. While they vary widely, all of them fit within a set of definitions agreed for IRFOL's work generally:

We have used the term 'open and distance learning' as an umbrella term for our sphere of interest. It covers distance education, open learning and the use of telematics in education. We have working definitions of each of these, although the way the terms are used varies with location: something called distance education in one place is called open learning in another. The definitions are:

> Distance education is an educational process in which a significant proportion of the teaching is conducted by someone removed in space and/or time from the learner.
>
> Open learning is an organised educational activity, based on the use of teaching materials, in which constraints on study are minimised in terms either of access, or of time and place, pace, method of study, or any combination of these.
>
> Telematics is the combined use of telecommunication and computer technology.

Hilary Perraton

Part I

1 What we found

Open and distance learning can use a variety of media and, as information technology develops, so the range of choice gets wider. Many open and distance learning programmes combine some face-to-face teaching with technology-based teaching. Managers are, therefore, faced with choices between technologies, and between mediated communication in one form or another and face-to-face teaching. The aim of this study was to inform the choices they have to make.

At the simplest, if we have decided to use open and distance learning, we can make comparisons between four sets of technologies. First comes print: for many purposes it provides the cheapest and most convenient way of recording teaching and making it available to students who are working at a distance, or away from a teacher. Next, material can be provided in sound, either on audiocassettes or, if an institution has access to broadcasting, by radio. Third, we have a set of different ways of using audiovisual communication: through videocassettes, through closed circuit television, as with videoconferencing, and through open circuit broadcasting. Fourth, computers can be used for a variety of different teaching purposes. This classification may be over simple, and even its boundaries may be blurred. Computer technology, for example, can be used to offer audio or video images, or to carry print. But it is a useful place to begin.

Comparing costs

The purpose of our research has been to develop tools that will be useful for educational managers. In doing so, we have concentrated heavily on examining the costs of different ways of running open and distance learning. Much of our argument, and much of the evidence that follows is about costs. We need therefore to begin with a disclaimer. It is no part of our argument to suggest that educational decisions should be taken on economic ground alone. Nor are we suggesting that we can leave aside questions of effectiveness. It would be rewarding - but would demand far more resources - to look at the comparative effectiveness of different approaches to open learning. We are, however, suggesting that it is easier to make sound educational decisions if we begin with an understanding of what they are likely to cost. The rest of this chapter therefore looks at the comparative costs of various different teaching media.

Our starting point is that the manager will make a choice between alternative technologies on the basis of the social and educational cases for choosing, say, print for part of a course, an audio recording for another part, and some form of computer-based learning for another and, in making that choice will want to know about their comparative costs. Furthermore, in choosing between media or technologies, the manager can be relaxed about the question of effectiveness: the research literature on the effectiveness of educational media shows consistently that the choice of medium does not affect outcomes in terms of learning (Clark, 1983). (We look at the question of media effectiveness more fully in chapter 3.)

As a result, the educational manager can choose between alternative technologies, confident that the choice is not likely to affect learning - though it may have major consequences for learners in terms of convenience, access, or motivation. That confidence makes it all-important to consider the cost of alternatives, and the different ways the costs for different media behave. The cost of each choice provides a vital piece of information to help make management decisions.

Of course, cost is not the only consideration. The choice of media will also be affected by questions of the appropriateness of a particular medium for the educational process and aims of the course. Each medium is likely to have strengths and weaknesses that appeal to a manger, and to the eventual students. Print, no matter how unglamorous, is convenient for students and teachers, easy to use, and demands no more than literacy, a press or its equivalent, and a postal system to become available to students. Audio and video have obvious advantages for presenting aural material, for demonstrating examples or offering simulations, and for altering the pace and texture of study. Broadcast radio and television, despite the inconvenience of their fixed hours, may be valuable for motivating students and for providing a shop window. An increasing number of institutions also want to have a shop window on the Internet. Alongside any pedagogical advantages of using computer-based teaching, of one kind or another, there may be institutional pressures to use computer links alongside other means of communication. Our concentration on cost is not intended to downplay the educational and social reasons for using one medium rather than another. Instead it is intended to provide neutral information that will allow managers to make trade-offs between the cost of the simplest option and the likely benefits of anything more sophisticated.

In order to identify and compare the costs of open and distance learning we need to overcome three difficulties. All are peculiar to open and distance learning and do not apply to the analysis of conventional education. First, as open and distance learning usually depends upon the production of teaching materials, that may be used over a number of years, we cannot simply divide the recurrent costs by the number of students, as we can if we want to calculate a crude, annual cost per student for conventional education. Second, if we want to look at cost effectiveness, we need to consider not just the costs of developing materials and supporting students, but also the total number of students likely to be enrolled over a number of years. Only with this information we can work out a cost per student. Third, within open and distance learning, we have an apple and orange problem. In order to make rational choices of medium, the manager needs to compare media that are, apparently, as different as a printed book and a videocassette.

To overcome these problems we have sought, as far as possible, to use a single, standard measure to compare the costs of different technologies - the student learning hour. Thus, in considering printed materials, for example, we have sought the best information on the number of hours that the average student will spend in working through the text. This makes it possible not just to calculate a cost per page - useful for comparing one text with another - but a cost per student learning hour. Similarly we have sought information on the time it will take to develop, say, an hour of teaching recorded on an audiocassette or the preparation of an hour of computer-based learning. Most of our calculations have therefore used the same common currency, comparing the costs required to provide for a given amount of study time using different media. A book may cost £20 000 to write and to produce and occupy a reader for forty hours. A television programme may last only for an hour but may cost £120 000 to create. The respective costs per learning hour are £120 000 per hour for television and £500 per hour for the book.

We were encouraged to accept the student learning hour as a common measure, despite its apparent arbitrariness, because it is actually in use. Increasingly institutions developing open and distance learning courses indicate the learning time the average student is expected to set aside for studying. Similarly, learning time is increasingly being used in relation to credit recognition and transfer. Within higher education in Britain, for example the credit accumulation and transfer (CAT) point system has been developed to compare degrees and modular courses within them, in part to facilitate student mobility. CAT specifications, with a formally stated rate of exchange with student learning hours, provide a possible planning framework for those working on the development of teaching materials.

Then we have found it useful to distinguish between two different uses of technology - as resource media or as communication media. We have used the term 'resource medium' for any medium which is used to convey instruction, presenting teaching material to students in what is principally a one-way mode of communication. By 'communication media' we mean the use of media for communication between student and tutor or among students. Resource media inform, communication media allow dialogue. Some media - print for example - lend themselves very much to use as a resource. Others - computer conferencing - are more likely to be used for communication.

Both resource and communication media are necessary for education but their costs behave differently. In using resource media we can expect to find some economies of scale. While some print costs, for example, rise with increasing number of students, for paper, reproduction, and distribution, much of the total cost represents academic staff time. This cost is fixed so that the cost per student falls as more students enrol. With most communication media, however, costs are a function of the number of students, or in some cases the number of groups of students. There are, for example, no economies of scale in offering telephone tutoring to students.

By carrying out a series of case studies, and examining them in the light of existing literature on educational cost-effectiveness, we were able to reach some general conclusions about the costs of both resource media and communication media. The case studies are summarised in table 1.1 and discussed more fully in Chapter 2.

Table 1.1: Case studies (overview)

Name of institution	Country	Course title/ Subject area	Technology configuration
Open University	United Kingdom	Studies in health and social welfare	Print, audio and video
Open University	United Kingdom	Mathematics	Print, television, video and CD-ROM
NKS	Norway	Adult secondary education	Print and video
NKS	Norway	Teacher education/ upgrading	Print and video
FVL	Germany	Business engineering	Print
ZEF Oldenburg	Germany	Professional development	Print
Anglia Polytechnic University	United Kingdom	Studies in health and social welfare	Print, television, video, Internet, videoconferencing, computer conferencing
Université de Dijon	France	Philosophy	Print and audio
Poltecnico di Milan	Italy	Engineering	Video-conferencing
ZEF Oldenburg/ UMUC	Germany/USA	Distance education	Online
Universita Oberta de Catalunya	Spain	Law	Print

The costs of resource media

Resource media, used to carry teaching to students, provide the backbone for open and distance learning. They form an indispensable framework, for their study, even where ample opportunities for dialogue are provided for communication media. Investment - especially in staff time but sometimes also in a particular technology - is necessary if teaching is to be recorded and made available through resource media. The manager therefore needs to be able to analyse and forecast the costs involved in developing and using resource media, and to see where it may be possible to achieve the economies of scale that they make possible. With our colleagues, we therefore looked at the costs involved in using various resource media: print, audio or videocassettes, open circuit television, and the use of computers in education. In each case we looked both at the fixed costs, which are principally the costs of developing teaching material and are unaffected by student numbers, and the variable costs, which are mainly for distribution, where costs vary with the number of students.

Fixed costs

We start with *print,* the simplest technology. Most teaching starts with the preparation of a text and the simplest and cheapest way of reproducing and distributing that text is still to use print. Even if we are developing computer-based teaching or writing computer software a text is usually the starting point. The preparation of a text forms a significant proportion of the cost of producing printed materials. Thus we have treated print as a default option, treating its costs as a point of comparison for the other media that may be available for open and distance learning.

On average we found that one hour of student learning, provided in the medium of print, costs £350 and that, as a rule of thumb, ten student learning hours demand some 50 pages of print. This means that 50 pages of print cost about £3 500. About half of it goes to the author, with the rest being required for the costs of instructional design and editing as well as the preparation of copy for printing.

Print remains the most important medium for distance teaching. Much material is distributed conventionally but it is now also possible to deliver teaching material to students on the Internet. Although we consider the use of computers in open and distance learning below, it is appropriate to look here at the implications of using the Internet as a distribution medium.

The Internet allows text presentation on the screen instead on the printed page. This saves the cost to the institution for distribution although it may also mean that the user prints out a visually inferior version of the text. The development costs of text on screen might be expected to be the same as for printing. They include writing the text, layout and design. However, course managers express reluctance to distribute text on the Internet, unless it uses some of the design options available in the digitised medium. It is assumed that learner expectations would be frustrated if

neither hyperlinks were edited in nor browsing facilities made available. The lesson from this is that the potential of a technology creates expectations, which exert an upward pressure on costs.

In the case study from Anglia Polytechnic University the Internet was used to present a text, which had been re-edited in hypertext format. The cost for the Internet version therefore had to include the authoring cost and at least some of the cost related to text design and layout. The APU experience suggests that the development costs double when a text is re-designed for the Internet.

Generally, therefore, we would expect the use of the Internet rather than conventional print at least to double costs, and quite often to increase them much more than this. A tenfold increase may not be unusual. The use of the Internet also transfers distribution (or, more strictly, reproduction) costs from the institution to the student, and may result in the student's having a lower quality of print once material has been printed from the screen. These disadvantages need to be set against the advantage of rapid distribution and the benefits of adding hyperlinks and other computer-based enhancements.

Both *audio and videocassettes* are of potential value for open and distance learning. We found only occasional use of audiocassettes, although reports on their costs have been made previously. The available costs suggest that the cost of preparing learning material for a similar number of student learning hours is about five times of producing print. (Broadcasting agencies, using higher standards of production, report a larger difference.) The increased cost is explained mainly by the amount of staff time needed to produce effective teaching materials in audio format. Video turns out to be a relatively expensive medium. We have reported one case where the video development costs is significant lower but it turned out to be a re-use of a live satellite transmission, the production cost of which were not included.

Open circuit television appears to be the least cost-effective of the media we examined. Indeed the role of television in distance education appears to have changed having become less an integral part of the weekly process of teaching and learning and more a window display to attract potential learners.

We have used the phrase *computer-based teaching* to cover a variety of different uses of computers within education. In looking at their costs, we run into an immediate difficulty as some computer applications cut across the neat distinction between resource and communication media. It may be possible to use a computer network, for example, both to carry resources from the institution to the student and to offer a tutorial service. For our purposes, we have found it convenient to distinguish between three broad categories of computer use: as a distribution medium, for interaction between the student and the computer, and for interaction between students and tutors. We will come back to the third category in looking at communication media.

First, as we saw in relation to print, we can use computers simply as a means of distributing material to students. We may do this by putting material onto a CD-ROM, or by using the Internet. In both cases, there may be pressure to offer something more than straightforward text, as the medium facilitates this. But, at this level, we are simply treating computer technology as an alternative way of distributing resource media, alongside physical methods of distribution.

Second, computers have been used in a variety of ways in which students interact with materials available through the computer and in which that interaction is at the heart of the learning process. (The early application of computers to education was dominated by computer-assisted learning in which students interacted with a computer program instead of a teacher.) Computers are being used in half a dozen different ways here. Computer-marked assignments are used by some institutions alongside tutor-marked assignments. Interactive computer-marked assignments are more complex and are designed to provide fuller information as feedback to students. Students may use computer tools, such as standard wordprocessing and spreadsheet programs. In order to help their study, they may use the computer to access databases. In contrast with these approaches, computer-assisted learning requires the development, or purchase, of programs that are designed to teach. In the case of interactive computer-assisted learning, these programs include items such as film or video simulations as well as text-based material. In all these cases, the student is interacting with a computer program rather than using the computer as a means of getting resources or communicating with an individual.

In our studies we found that materials had most often been made available in CD-ROM format. CD-ROM can be designed as a highly interactive medium with consequent high development costs. The cost per student learning hour varies considerably, according to the sophistication of the use of the medium. We found some development costs of £13 000 per student learning hour and know of cases of investment of nearly £20 000 per student learning hour. Data on cost depended here on rather subjective information from course designers who have rarely kept good data on the amount of time spent in developing teaching material. Our best estimate from the case studies is that it costs forty times as much to produce material in CD-ROM format as in print. Despite this high fixed cost, CD-ROM proved to have lower development costs per student learning hour, in the cases studied, than video or television. Development costs of CD-ROM may come down where it is possible to develop shells (a sort of CD-ROM template), which can be re-used for different purposes.

We were able to examine the cost implications of a number of the possible options available for computer-based teaching. To help comparison, we refer to one hour of student learning. These calculations of learning time are based on the intentions of the course designers rather than on empirical research of the actual time spent by students. We found some costs for preparing computer-marked assignments, for customising software, for work on databases and for computer-assisted learning.

We did not find disaggregated costs for the preparation of computer-marked assignments. Widely varying costs were quoted for interactive computer-marked assignments. Figures were given which range from about £300 up to £1 500 per student learning hour. An indicative figure of £900 may serve as a benchmark cost.

Where existing generic or specific software is bought in it usually needs to be incorporated into a course programme and consequently needs to be customised. A benchmark figure for such software customisation work is £150. Where extensive customisation is needed, with more software development costs, then the cost may rise to £2 000 to £8 000.

When databases have to be made available in searchable form, the data must be indexed and search tools have to be developed. Costs are consequently of two types: software development of search tools and the editing tasks of putting databases together and indexing them. The costs per student learning hour were estimated to be £150 for development of search tools and a further £150 for editing tasks. For a searchable database an indicative figure is therefore £300.

Table 1.2: Computer-related costs Currency: sterling

	Cost range per student learning hour	Mid-point cost per student learning hour
Interactive computer marked assignments	300 to 1 500	900
Spreadsheet; packages		150
Searchable databases	Software input 150 Editing input 150	300
Computer assisted learning (CAL)	3 000 to 20 000	10 000
Multimedia CAL		20 000
Computer mediated communication (CMC)		100
Customisation of software	2 000 to 8 000	5 000

Source: own case studies

Benchmark figures for computer-assisted learning allowing simulation and modelling, are likely to be substantial. A benchmark figure would be £10 000 but figures of as high as £20 000 have been reported. These higher costs become more likely where film clips or other multimedia elements are included. Editing also becomes more complex so that additional editorial input ranges from £300 to £1 500. Thus the total cost of multimedia computer-assisted learning can be near to £30 000. (The costs we found are set out in table 1.2.)

We got mixed reactions from students about the use of CD-ROM. Some have reported that the use of interactive media slows the process of studying. There have been demands from students for printed copies of materials, as well as CD-ROM versions, because of their greater convenience. Students at a British Open University seminar, examining the use of computer technology, were however enthusiastic, some to the extent that they made further course choices dependent on the use of CD-ROM as a medium. The university has used CD-ROM for social science as well as natural science. One course, for example, on social investigation in nineteenth century Britain, used CD-ROM to provide students with a complete archive of the work of the 19th century social investigator Charles Booth both as handwritten original documents and in searchable digitised form.

Despite the wide range of costs reported, three conclusions are clear. First, in planning for the use of computer-based teaching, the manager needs to be very clear about the nature of the computer use proposed. If it is merely to provide a convenient means of distributing teaching material to students then, in principle, costs need be no higher than for print. In practice, however, course designers - and students - will expect to take advantage of the capacity that computers give for providing information in different ways. Development costs will then rise, and may do so dramatically. Second, the total cost of a programme using computer communication will be affected by decisions about the use of it for individual or group contact with students: we come back to this below in considering communication media. Third, unlike broadcasts, computer-based communication is unlikely to attract a wider student audience. The increased costs we have found will therefore need to be justified either in terms of the pedagogical benefits they bring.

We can now pull together the evidence on the fixed costs associated with each of our four sets of media. This is given in table 1.3. It shows the typical costs per student learning hour we found for the development of teaching materials in a range of media. As already proposed, we then have shown these as a multiple of the cost of preparing material in print, our proposed default option. The figures provide some basic guidance for the educational manager in estimating the investment required for various alternatives and, by implication, the critical importance of considering the size of the potential audience in relation to the choice of medium: the more students, the easier it is to justify moving away from the default option of print. To complete the resource-media picture we need next to look at the variable costs associated with each medium.

Table 1.3: Resource media: fixed costs Currency: sterling

Media	Cost/SLH[a, b]	Cost/SLH as multiples of cost/SLH(print)
Print	350	x 1
Internet	700	x 2
Audio	1 700	x 5
CD-ROM	13 000	x 40
Video	35 000	x 100
TV	121 000	x 350

Source: case studies. Notes: a: cost/SLH stands for *cost per student learning hour;* b: costs here and in other tables, are in £sterling.

Variable costs of resource media

While the fixed costs for most resource media are of the greatest significance for the planner, some media also require expenditure on reproduction - as contrasted with development and production of a master version - and on distribution. These costs vary with the number of students. We have brought together exemplary figures in table 1.4.

In some cases, here, we have moved away from an attempt to cost everything in terms of student learning hours and instead used a standard unit, such as 48 pages of text or a single audiocassette in order to have a convenient and usable benchmark. In the case of open circuit radio or television we show distribution cost as zero on the assumption that transmission costs are met by a broadcasting agency and seldom fall as a charge on an educational institution. In the case of CD-ROM it is unrealistic to give a number of student learning hours per disc. A disc can, for example, provide for vastly more student learning hours if it simply contains text than if it consists of computer animations, music or film.

Table 1.4: Resource media: variable costs Currency: sterling

	SLH	Unit	Reproduction cost per unit	Distribution cost per unit	Aggregate unit cost per unit
Print	10	48 pp	1.00	0.50	1.50
Radio	1	1 hour	none	none	none
Television	1	1 hour	none	none	none
Audio cassettes	1	C60	1.00	1.00	2.00
Video cassettes	1	E60	2.50	2.00	4.50
CD-ROM	vary	disc	3.00	1.00	4.00

Source: own case studies; production costs include labour and material costs.

Costs for communication media

When we turn to communication media we are principally concerned with variable costs. For each bit of support offered to a student, or opportunity provided for dialogue, there is normally an additional cost, largely made up of the cost of tutorial time. In the case of technology-supported communication, for example videoconferencing or computer-based communication, there is also likely to be a cost for equipment and for line charges. But, for the manager, the vital point is that the costs here are ones that rise inexorably with the number of students. If the costs per student for communication media rise as high as the costs that would be required for face-to-face teaching, then open and distance learning can never have an economic edge over conventional teaching. Thus while these figures are in pounds and pence, not the hundreds or thousands of previous tables, they are costs that the manager critically needs to control.

In table 1.5 we set out some indications of the level of costs for communication that have been reported. In this table we have assumed that academic labour is paid at £25 per hour: readers in jurisdictions with very different salary levels would need to substitute figures here. In order to facilitate comparison, and make it realistic, table 1.5 sets out the costs for a notional course that has 5 hours of computer-mediated communication, 1 hour of videoconferencing, 8 hours of face-to-face tutorials and four assignments to be marked by a tutor.

Table 1.5 Costs of communication media Currency: Sterling

Communication media	Unit of inputs	No of units	Cost per unit	Formula and unit costs (variable cost per student)	Total unit cost
Computer-mediated communication	Hour of tutorial time	5	25	$\frac{\text{cost/UE}}{\text{group size}} = \frac{25}{20} = 1.25$	6.25
Video-conferencing	Hour of staff, depreciated equipment, line time	1	160	$\frac{\text{cost/UE}}{\text{group size}} = \frac{160}{20} = 8$	8.00
Tutorials	Hour of tutorial time	8	25	$\frac{\text{cost/UE}}{\text{group size}} = \frac{25}{20} = 1.25$	10.00
Tutor marked assignments	Assignment marked	4	12	Cost/UE = 12	48.00
Total					80.25

Note: UE = unit equivalent

We have calculated a cost for each unit and also assigned to it a number of student learning hours. In the case of a tutorial or a videoconference this is a realistic and useful measure. In other cases, however, it may be arbitrary or even misleading. A tutor-marked assignment, for example, may require ten hours work from the student. For the manager, however, the critical issue is not the length of time taken by the student but the amount of time the tutor spends marking it and therefore the unit cost per assignment. There is a further difficulty in estimating the cost per student learning hour for computer-mediated communication. In principle, it should be possible to ask tutors to spend one hour responding to the volume of computer communication generated by students in response to a particular section of a course, and pay the tutor accordingly. In practice tutors are unwilling or unable to confine their responses to computer communication or ration the time they devote to this part of their work. As a result, while in theory it may be possible for a tutor to respond in one hour to the work done by, say, twenty students in a computer conference in just the same way as might be possible in a videoconference or face-to-face, in practice tutors are likely to spend up to five times as long responding to computer communications.

Three other major - if obvious - points emerge from the figures. First, the marking of assignments has the highest unit cost as it is the only example in our table of one-to-one communication. Second, where there is an opportunity for group study, cost per student is very sensitive to the size of the group. We have assumed, for example, that a videoconference will attract an audience of twenty; if only ten come, the cost per student doubles. Third, because of the costs of equipment and line charges, tutoring that depend on electronic communication, such as videoconferencing, is likely to have higher costs per student than conventional face-to-face tutoring. It is likely to become more cost-efficient as more sites are included. However, there is a trade-off with effectiveness: the more sites are included, the more there is a tendency for a videoconference to turn into a one-way medium of communication. It may, however, have a potential advantage in some circumstances through savings of travel costs and the opportunity costs of the time students spend travelling.

Summary

In the light of our case studies, and of existing data, we have drawn distinctions between resource media - the use of media to carry teaching materials to students - and communication media - allowing two-way interaction. In order to facilitate comparison between costs, especially of resource media, we have looked at the costs involved in providing for one student learning hour for each of the media on which we have data. Taking the cost of a text, and reproducing it in print, as a basis, or default option, the evidence shows that using any more sophisticated medium is likely to increase the development costs for resource media. In short, we need solid educational arguments for using anything other than print, and solid economic ones to justify our selection of media. To

complete the cost picture we need to look at the reproduction and distribution costs for resource media and at the costs of communication media.

The figures demonstrate the importance, for the planner, of examining the educational case for using each medium other than print in making resources available for students, and of planning the amount of interaction between tutors and students that is to be built into the course, and offered through communication media. In the following four sections we examine ways of applying these lessons.

2 How we found it

In examining and interpreting the evidence on the costs of open learning we made use of the existing literature on the subject and, in its light, carried out our own case studies. In this chapter we look at the conclusions that can be drawn from the existing literature, examine the use of cost-effectiveness analysis in education and look at the debate on the functions of various educational media. We then go on to look at the mathematical basis of our own research work and to summarise the case studies that were at the core of it.

What was already known

The literature on cost issues in open and distance learning is still very limited and little of it provides empirical data. Two other bodies of literature, also impinging on the question of cost-effective media choice, are growing more vigorously: pedagogical literature exploring the teaching capabilities of the new media and more technically oriented literature on media and educational technology. (We examine the literature in more detail in the bibliographical note page 144).

Much of the early literature concentrated on comparisons between distance and conventional education. The infiltration of educational technologies into distance education, not only in dedicated institutions but also in conventional institutional settings (often referred to as resource-based learning or flexible learning), has however forced a shift of attention from questions of institutional cost-effectiveness to those of cost-effectiveness at course level. Managers are more interested in working out the costs of a course than in comparisons between different kinds of institution. On the level of institutions we have a more or less established consensus on which indicators can be used to compare cost-effectiveness across institutions (i.e. cost per student and cost per graduate). At course level, the question re-emerges: what can be agreed upon as a cost-effectiveness indicator for a specific course? This in turn generates questions about the comparative costs and effectiveness of alternative educational technologies or media.

There is a long tradition of research into the comparative effectiveness of different educational media. As distance education has to rely on media to bridge the distance to the learner, it is necessary to examine whether you can teach as effectively through media as in the conventional classroom. A substantial body of research has been carried out over many years which consistently shows that there are no significant differences between the educational effectiveness of different media (Chu and Schramm, 1968; Russell, 1997). Perraton (1987) summarised this line of argument as media equivalence theory. It was radicalised by Clark in the claim that media do under no

circumstance affect learning (1983). This was criticised in a widely quoted article by Kozma (1991), which claimed that media may well influence learning. The debate is succinctly summarised by Carter (1996).

There is a tension here between the solid research findings of media equivalence - that no medium can be expected to be more effective than another (Chu and Schramm, 1968; Russell, 1997) - and the pragmatic view that particular technologies have advantages for particular purposes (cf. Kozma, 1991; Clark, 1983). From the very beginning distance educators have been aware of particular strengths and weaknesses of technologies when applied to different tasks and for different groups of learners. Though in principle the change of medium alone does not guarantee any effect on learning, practitioners argued that different media had different capacities. In order to put the debate about the selection of media into an educational context, we therefore look below at media capabilities.

Before doing so, we can sum up with three broad conclusions from the literature, which formed the starting point for our own review. First, we cannot choose between educational media on the simple assumption that any one medium will teach more effectively than another. A wealth of research has demonstrated that there are no across-the-board findings that will direct us always to use, say, classroom teaching, or print, or computers because of their inherent educational superiority. We need something else to guide us. That guidance is likely to come from a consideration of both pedagogy and economics. Second, there are often practical arguments that will affect our choice of medium. They may have different effects on motivation. Some are more convenient or accessible to students: using television may sound attractive and exciting but has its drawbacks if students have to watch programmes late at night or early in the morning. And there may well be advantages in mixing media in order to benefit from the particular strengths of each. Third, our choice is likely to be affected by information about costs. The costs of open and distance learning behave differently from the costs of conventional education. Where we are using communications media, from print to computers, to distribute teaching material to students we may expect economies of scale through their use that cannot be achieved in conventional education.

Studying cost-effectiveness analysis

If we want to justify the choice of one teaching medium rather than another we will probably want to look at the outcomes: is teaching effective and are achievements improved? Educators are little impressed when managers argue that broadcasting can significantly cut the cost per student and, are more likely to ask questions about educational effectiveness and about the quality of teaching. Educators disengage from the discussion on media choice if effectiveness is ignored. Given their

central role in the planning and implementation of distance education, course managers who fail to engage the commitment of educators are unlikely to be successful. The need to bring together the different cultures, of economics and finance, and of education, is reflected in the keyword cost-effectiveness.

Our research began here. Fortunately, a procedure was available to compare the cost-effectiveness of different educational strategies.

Cost-effectiveness analysis: the methodology

The procedure is called cost-effectiveness analysis. It was developed in the United States as a management method to decide between different strategies. Originally it was developed by the Pentagon in order to arbiter between rivalling bids for funds put forward by different sections of the US Army. It was then used in public administration and later, like cost-benefit analysis, filtered into education (Levin, 1983).

The concept is simple. You have different strategies from which to choose, to achieve your objective. The degree to which the objective will be achieved is to be measured and indicates the effectiveness of the strategy used. The cost of the strategy also is measured. From this a cost/effectiveness ratio can be derived. Repeating the same procedure for each strategy provides us with a set of cost-effectiveness ratios, which can be compared. Other things being equal, preference is given to the strategy with the lowest cost-effectiveness ratio. Thus cost-effectiveness analysis looks at the comparative cost of using different approaches to achieving the same result.

This type of analysis was intended as a management strategy. This means that costs and degrees of effectiveness would have to be estimated beforehand. In the case of the original military context this meant that the costs of the weapon systems had to be estimated in advance and the effectiveness would have to be inferred on the basis of their technical specifications.

Cost-effectiveness analysis in education

Obviously such an approach sits uneasily with education. The outcomes of educational processes are difficult to measure. Even where they are measured, educators argue that they do not reflect the whole of the educational experience. Most importantly many educators object to a view of the educational process as a technological one where certain inputs produce predictably consistent effects. They object not only because it does not reflect their experience but also because it conjures up an image of technical manipulation rather than of subjectivity and freedom.

Given this double problem (measurability and the causal relationship of inputs and outcomes), it is not surprising that cost-effectiveness analysis in education has been restricted to specific areas of

evaluation and research. The major application of cost-effectiveness analysis in our area was in comparing the cost-effectiveness of distance-teaching institutions to their conventional alternatives using the cost per graduate as a cost-effectiveness indicator (e.g. Jamison and Orivel, 1982).

Cost-effectiveness analysis and the hypothesis of media equivalence

A number of efforts have been made to apply cost-effectiveness analysis to the problem of media choice. One approach was to vary media inputs and see if the change of media had any effect on achievement. The table 2.1 presents a widely quoted example of such a cost-effectiveness comparison (Rumble, 1997, based on Levin *et al.*, 1987). It looked at the evidence on various alternative approaches to raising educational effectiveness including using computers, changing class size, increasing instructional time, and experimenting with different approaches to tutoring.

Table 2.1: Example for a cost-effectiveness calculation

		Effectiveness[b]	Costs[c] ($)	Cost-effectiveness[d]
CAI[a]		1.2	119	1.01
Cross-age tutoring				
	peer component	9.7	212	4.58
	adult component	6.7	827	0.81
Increasing instructional time		0.3	61	0.49
Reducing class size				
	from 35 to 30	0.6	45	1.33
	from 30 to 25	0.7	63	1.11
	from 25 to 20	0.9	94	0.96
	from 35 to 20	2.2	201	1.09

Source: adapted from Rumble (1997: 179, Table 14.7); this table was adapted from Levin *et al.* (1987).
Notes: a: CAI Computer aided instruction; this meant 10 min drill exercises with the computer each day; b: estimated increase in effectiveness measured in terms of gain in months of students' academic achievement; c: annual addition cost per student of intervention; d: estimated effectiveness in months of gain in achievement for each additional $100 expenditure per student.

Generally the results of such research show that no such relationship can be established in a consistent manner to recommend one medium over the other. Raising effectiveness cannot be expected from merely changing the teaching media. This result is consistent with the media equivalency hypothesis (Perraton, 1987), which states that media have little or (in a more radical version, Clark, 1983) no effect on learning.

Efficiency and effectiveness

In discussing cost effectiveness we need to distinguish between efficiency and effectiveness. Efficiency is a concept coming from input-output analysis. Generally you have a process (a manufacturing process), into which inputs are fed (say energy and primary materials) and out of which come outputs (say cars). A process A then is said to be more efficient than B if the ratio of inputs over outputs of A is smaller than that of B. More generally, the most efficient process is the one with the lowest ratio of input over output. To speak of ratios obviously implies that inputs and outputs are measurable. If inputs can be measured in monetary form, we can define cost-efficiency as the cost of inputs divided by number of outputs. When comparing several such processes the one with the lowest ratio is said to be the most cost-efficient.

We can distinguish between price efficiency and technical efficiency (Mace 1992 and 1996). To achieve price efficiency one has to minimise the costs of inputs while keeping the output specifications constant. (Managers in higher education in England and Wales will easily recognise the government requirements for efficiency gains here.) To achieve technical efficiency one has to increase the level of output without any change in inputs. These economic concepts, drawn from studying manufacturing, are increasingly being applied to education.

Efficiency is about doing things right and effectiveness is about doing the right things (Drucker, 1974). The concept of effectiveness introduces a framework of objectives, against which the success of one's activities has to be measured. The measure of output here is the extent to which an objective has been realised. The effectiveness of teaching can, at a crude level, be assessed by a test. The test scores then define the percentage of effectiveness. If these are linked with the costs of the inputs, then it is possible to develop cost-effectiveness ratios. When comparing two strategies according to their cost-effectiveness, we have to compare numerators and denominators of the respective cost-effectiveness ratios. We can distinguish four cases in which we compare approach A - say the use of a non-conventional teaching technology - with approach B - following conventional methods.

1) Cost unchanged or reduced and effectiveness unchanged or reduced (Cost A <= cost B and effectiveness A <= effectiveness B)	2) Cost increased, effectiveness unchanged or reduced (Cost A > cost B and effectiveness A <= effectiveness B)
3) Cost unchanged or reduced and effectiveness raised (Cost A <= cost B and effectiveness A > effectiveness B)	4) Cost increased and effectiveness raised (Cost A > cost B and effectiveness A > effectiveness B)

The manager can easily reject the use of approach A in case (2), with increased costs that yield no improvement and adopt approach A in case (3) where there are improvements without more expenditure. Cost effectiveness will not, however, help us in cases (1) and (4), and the manager will need to look elsewhere for guidance.

Studying media capabilities

As we saw, in a counter-current to the claim that media do not affect learning, educators have continued to explore the strengths and weaknesses of media in practice. Paradoxically writers who on one page claim that 'media cannot affect learning under any condition' discuss on the next page how to harness the specific strengths and capabilities of a medium for the purpose of teaching. (Other writers suggest that media do not affect learning but nevertheless they should be mixed to optimise these effects. They suggest that, if individual learners have preferences for one medium rather than another, a mixture is likely to suit the individual needs of a larger number and so raise effectiveness for the whole group.)

In the discussion of cost structures in chapter one we distinguished between resource and communication media. The distinction has implications for the design of teaching and learning. Educational content needs to be presented and students engaged with the subject matter. Students are likely to need help in understanding the content. This help is generated by interactivity, either internal interactivity, where the educational material is organised to engage the learner, or external interactivity with the teacher and possibly the peer group. External interactivity also permits dialogue that may take the learner away from and beyond the pre-prescribed content.

Resource media can be seen as presenting learning material to students, introducing the essential concepts and subject matter of a particular area of study and the intellectual or practical tools or methods of working that are appropriate to it. Different content may require different media capabilities for presentation: a course on Renaissance art needs to present visual images, while a course on Chinese phonetics may need audio media. A text is likely to be essential for virtually all educational presentation as the most important medium for presentation of concepts.

Students then need opportunities to test and check their understanding. This experience is facilitated by means of either internal or external interactivity. By internal activity we mean a process undertaken by the student alone, which goes beyond passive reading, such as working through examples set out in the text. The level of internal interactivity varies across the media: it starts with in-text questions and multiple-choice forms of self-assessment in print. Digitisation of text may provide opportunities to increase internal interactivity. In literature research or sociology, for example, the browsing of large data bases, on the computer, may be of particular value. Activities such as generating graphs of functions in mathematics, or simulations in economics, made possible with computer-based learning, can also be used to increase internal interactivity.

Table 2.2: Media capabilities I

	A Reading B Listening C Viewing D Dynamic images				A In-text questions B In-text activities C Self assessment D Browsing E Simulations					A Discussion B Assessment C Collaboration D Witness learning				
	Presentation				*Internal interactivity*					*External interactivity*				*Total SLH*
Resource media	A	B	C	D	A	B	C	D	E	A	B	C	D	
Print	148				15		5							168
Radio														
Television			2											2
Audio														
Video														
Computer-based teaching														
Hypertext	10				5		5							20
Computer-marked assignments (CMA)							5							5
interactive CMA					10	5	5							20
Computer tools														
Computer-searchable databases														
Computer-assisted learning (CAL)														
Multi media CAL				10			5							15
Communication media														
Computer-mediated conferencing (CMC)										5				5
Videoconferencing														
Tutorials														
Tutor-marked assignment											40			40
Subtotals	158		2	10	30	5	25			5	40			
Totals	170				60					45				275

Notes: The shaded area indicates the media capabilities. For example, television supports presentation but does not facilitate interactivity. CMC on the other hand, though allowing presentation, is strong in facilitating external interactivity.

External interactivity may include interaction between student and tutor or interaction among students. The former allows for individual questioning and discussion, external assessment, and monitoring as well as enabling tutors to offer individual encouragement and support to students.

Student:student interaction allows witness learning, where the student can observe other students' interactions with the tutor and peer collaboration. (It is interesting to note that this mode of learning, so prevalent in conventional education, is referred to in computer mediated conferencing rather scornfully as 'lurking'.)

Table 2.3: Media capabilities II

	Attending	*Practising*	*Discussing*	*Articulating*	Totals
Resource media					
Print	150				150
Radio					
Television	2				2
Audio					
Video					
Computer-based teaching					
Hypertext	20				20
Computer-marked assignments (CMA)		5			5
interactive CMA		20			20
Computer tools					
Computer-searchable databases					
Computer-assisted learning (CAL)					
Multi media CAL		10			10
Communication media					
Computer-mediated conferencing (CMC)			5		5
Videoconferencing					
Tutorials					
Tutor-marked assignment				40	40
Totals	172	35	5	40	252

Source: The model links student activities to media. It is based on a presentation of Laurillard, 1993 at the Regional Office of the OU in Cambridge.

Managers may seek to match their choice of resource medium, used for presentation of the subject matter, to its content and will then want to provide appropriate opportunities for internal and external interactivity. A number of attempts have been made to match teaching purposes against particular media, taking account of the advantages and disadvantages of a particular medium for presenting content or encouraging interaction. In table 2.2, which sets out the allocation of time within a particular course to different media, the educational manager has made deliberate choices

of the medium to be used for presenting material to learners, for internal interactivity and for external interactivity. The main teaching burden is carried by text - with 160 student learning hours out of a total time of 275 hours - but a wider range of media are used to encourage internal interactivity by the student.

Similar formats, varying in their complexity, have been proposed in the literature and used in practice. Laurillard (1993), for example, has developed a model in which the advantages of particular media are examined in relation to some twelve aspects of teaching and learning. A somewhat simpler model is set out in table 2.3 and based on processes developed at the British Open University. It assumes that we can usefully distinguish between four different activities in the part of a student: attending to the teaching material (e.g. reading, listening, viewing), practising what is presented (e.g. solving problems, answering questions), discussing the subject matter, and articulating what has been learned and their own perception and understanding of it (e.g. through tutor-marked assignments). In this example, too, print is mainly used for the presentation of material while computer communication is used to enable students to practise and discuss it. The right hand column of the table summarises the distribution of learning hours to each medium.

When tables like this are combined with information on cost per student learning hour (as in table 4.7), they can be used as the starting point for a rapid cost appraisal. This is outlined in some detail in chapter four.

Costing methodology

In order to use a cost-effectiveness approach to educational planning, and take advantage of what we know about the qualities of different teaching media and their costs, we need now to look further into techniques of analysing and comparing costs. As noted in chapter one, these techniques are necessary for any economic or financial analysis of open and distance learning, or of computer-based teaching, because their costs are different in kind from those of conventional education.

The total cost function

We can classify costs as fixed or variable. Fixed costs are those that remain the same, regardless of the number of students. Variable costs are those that vary with the number of students, rising as more students are enrolled. If, for example, it costs £50 000 to make a 25-minute television lecture on Fourier Transformations then this is a fixed cost, unaffected by the number of students who watch it. Conventional class teaching provides a contrast. As student numbers rise, more teachers need to be employed and paid. Their salary costs – and so the greater part of conventional educational costs – are variable. In the simplest cost model, costs are either fixed or variable. The total costs for an educational project, for a given number of students are therefore made up of the

fixed cost plus the variable cost multiplied by the number of students. We can write this in an equation:

Equation 2.1:

$TC(s) = F + V \times s$

where	TC	stands for:	total cost
	F	stands for:	fixed cost
	V	stands for:	variable cost
	s	stands for:	the number of students

The average cost function

We can calculate the average cost per student in the same way. The average cost (AC) is the total cost divided by the number of students or the sum of the fixed cost divided by the total number of students and the variable cost per student. This is shown in the following equation:

Equation 2.2:

$$AC = \frac{TC}{s} = \frac{F + (V \times s)}{s} \Rightarrow$$

$$AC = \frac{F}{s} + V$$

This equation makes it possible to see the economic strength of open and distance learning. As student numbers increase, so the fixed costs can be shared among an ever-growing number of learners, thus gradually reducing the average cost per student. Provided that the variable costs of distance education - for tutoring or the distribution of materials in particular - can be held down, it may therefore bring economies of scale.

Distance education may be attractive to policy makers because the composition of fixed and variable costs tends to differ from that of conventional education. Distance education is associated with comparatively higher fixed costs and lower variable costs. It needs more substantial investment up front for course development but these costs are then spread over an increasing number of students. A case in point is a book. It costs more to write a book and design it than to

deliver a lecture. But the replication costs of the book may be low whereas in the alternative case for each batch of new students new lecturing costs are incurred.

The behaviour of costs for distance education and for conventional education are set out in figure 2.1 and 2.2. Figure 2.1 shows how, with a small number of students, the total cost for a distance education programme may exceed that of conventional education. As student numbers grow, however, the heavy fixed cost becomes a decreasing proportion of the average cost per student (Figure 2.2). In this example once there are over 31 000 students, the average cost per student of distance-education falls below that of conventional education. We can sum up that we will expect the fixed costs of distance education to be higher than those of conventional education but the variable costs lower.

Adopting the convention that the subscript DE denotes distance education and CE conventional education, we can express this as

$F_{DE} > F_{CE}$ and $V_{DE} < V_{CE}$

We can draw practical recommendations from this. We may urge managers to watch the variable cost. If we allow this to be too high it may be difficult ever to achieve the economies of scale that give distance education a potential economic advantage. The combination of high fixed costs and high variable costs cannot be competitive. An alternative approach to this is to stress the importance of the break-even point, where costs per student are the same for distance education as for conventional education and ensure that it is well below the likely maximum enrolment level. If we cannot expect to achieve the break-even point, the costs of distance education will remain above those of conventional education. (The break-even point is marked with an arrow in figures 2.1 and 2.2) We can find the break-even point mathematically by solving the equation $AC_{DE} = AC_{CE}$ for s.

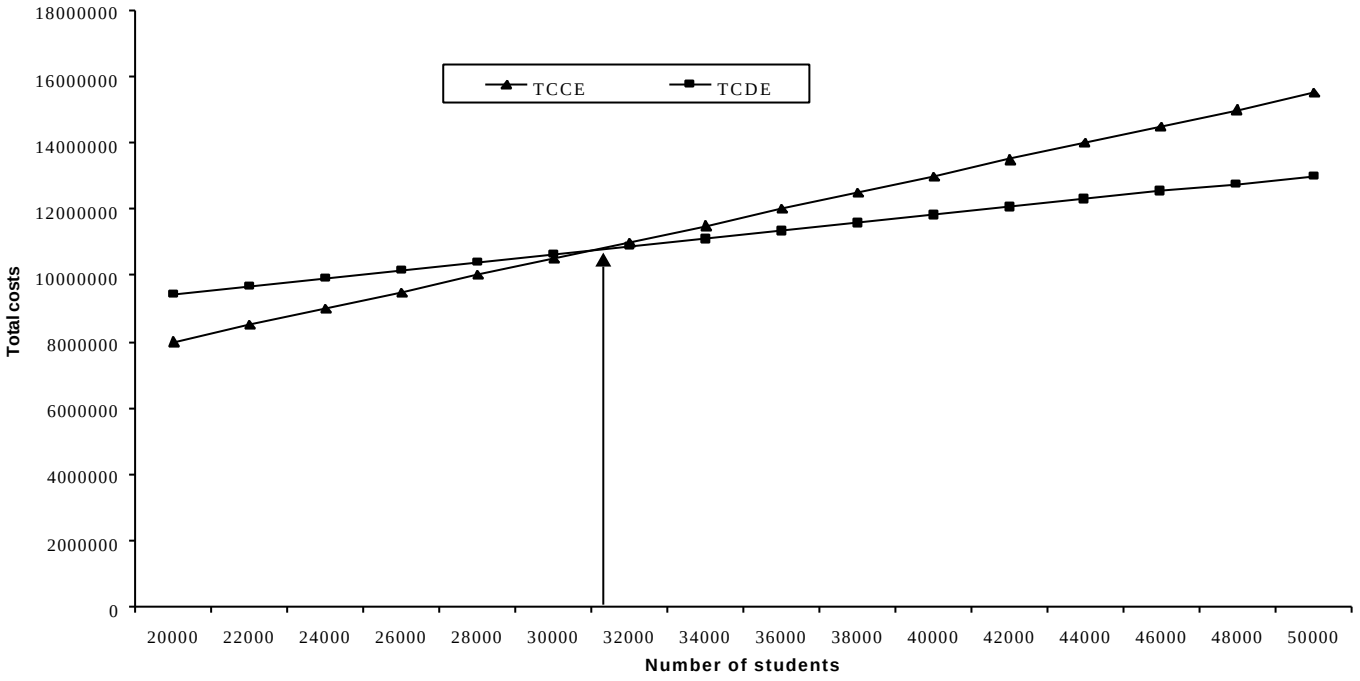
We get:

$$\frac{F_{DE}}{s} + V_{DE} = \frac{F_{CE}}{s} + V_{CE} \Rightarrow$$

$$\frac{F_{DE} - F_{DE}}{s} = V_{CE} - V_{DE} \Rightarrow$$

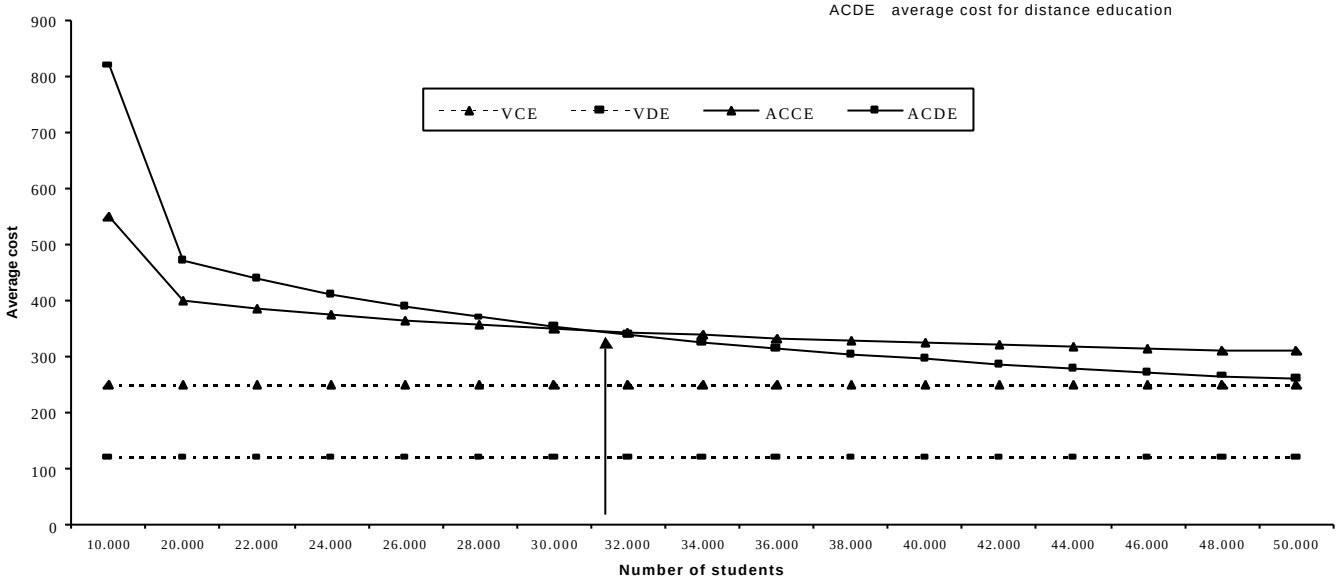
$$s = \frac{F_{DE} - F_{DE}}{V_{CE} - V_{DE}}$$

Figure 2.1: Total cost graph



VCE variable cost for conventional education
VDE variable cost for distance education
ACCE average cost for conventional education
ACDE average cost for distance education

Figure 2.2: Average cost graph



Model and reality

From this excursion into the economics of distance education it could be concluded that, to make distance education outperform its rival in terms of average costs, only a few benchmark rules need to be observed:

Keep the unit cost of your teaching strategy below the unit cost of any alternative;

Keep the fixed costs small enough so that the break-even point is smaller than the likely maximum enrolment level.

There are, however, some complications. Lowering fixed costs (e.g. by shifting from CD-ROM to print as means of delivery) may predictably slide the break-even point to the left, making it possible to break even with a smaller student enrolment. But the course may lose so much of its attractiveness that enrolment drops below the level required to break even. Again, extensive student support services may increase average costs per student but at the same time reduce drop-out rates and so lower the average cost per graduate. And, of course, questions of scale are critically important. Heavy investment in materials development can be justified for large numbers of students.

Research methodology

So far we have been drawing a general distinction between conventional and distance education, an approach that has been used in comparing the cost effectiveness of the two approaches generally. Within distance education we need to go on and distinguish those parts of its systems, of materials and of student support, that have fixed and variable costs.

Student support costs are generally variable. (We noted in chapter one that, where support is given to groups of students, the cost will vary with group size.) They are likely to include the cost of marking assignments - tutors' pay - and the use of communication media for student support.

Some of the costs involved in the development, production and distribution of teaching materials are fixed and some variable. The initial costs of developing teaching materials are fixed. For some media there is further a production, or better still reproduction or replication cost, which varies with the number of copies made. Thus, with printed materials, there is a variable reproduction cost while a television programme has only fixed costs. Distribution costs are also variable.

This cost classification allows us to interpret Equation 2.1 and Equation 2.2 in a way appropriate for distance education. We get:

Equation 2.3:

Total cost = Development cost + (Unit cost of Production + Distribution + Support) x Number of students

Equation 2.4:

$$\text{Average cost} = \frac{\text{Development cost}}{\text{Number of students}} + \text{Unit cost Production} + \text{Distribution} + \text{Support}$$

Especially Equation 2.4 provides a good guideline for data collection.

Our research

Our research included both an examination of existing knowledge about cost effectiveness - briefly summarised above - and a set of case studies carried out with colleagues within a number of European colleges and universities that are using open and distance learning. Gathering information from a group of institutions means that our findings reflect general experience, rather than being limited to a single approach or single educational philosophy. But this in turn creates problems; we have had to find an approach that can be used under widely differing circumstances and to choose indicators, or measuring rods, that are generally applicable.

For the most part, following standard techniques of micro-economics as they have been applied to education, we have collected data that separates fixed and variable costs and then looked at the number of students following a particular course. This makes it possible to determine the cost functions discussed above and so look at the effects of different choices of educational media in relation to the numbers of students likely to be enrolled. In order to facilitate comparisons across media and across disciplines, we have then examined the cost per student learning hour and, where courses use a variety of media, the cost that can be attributed to each medium.

Thus, our findings, on the costs of both resource and communication media, are based on a set of case studies, eleven of which appear in the second part of the book. They were drawn from seven European countries and range from mathematical modelling to pre-school education. The media used vary widely although all but one include a strong print component: despite the rhetoric about new media, print remains central for much open and distance learning.

The first two cases are taken from the British Open University (UKOU). It was founded in 1969 and now has nearly 160 000 students, including more than 20 000 from outside Britain. It offers degree courses across a wide range of disciplines, using technologies from print to computer-based teaching, and has gained a high reputation for the quality of its teaching material. We were given

access to cost data for several courses, two of which are included in part II. One of them looks at a course in social sciences, which is largely print-based though some video input is provided. The other course is taken from mathematics and includes CD-ROMs, television and videotapes besides print. Since the OU does not record cost per medium it was difficult to calculate costs by medium. However, from the data available it was possible to estimate the costs for the non-print media, - television and CD-ROM. What can be seen is that the cost of material development per student learning hour at the OU is quite high though average costs are competitive, because of the relatively high enrolment on these courses.

NKS Fernundervisning in Norway is a well-known private provider of post-secondary education working closely with the public sector. The history of the NKS goes far back to 1914 when E.G. Mortensen founded a correspondence school in Oslo. It is a much smaller institution than the Open University with lower enrolments. Its teaching is overwhelmingly print-based with some use of tapes and cassettes. Our case study refers to two courses.

The next case study comes from the Fachhochschulfernstudienverbund der Länder (FVL) in Germany. FVL is a consortium of institutions, founded after 1994 to pull together the resources of technical universities in the former East Germany. We were given access to cost data, which allowed us to estimate the costs of a complete degree course (business engineering). This course is largely print-based but with approximately 25% of face-to-face teaching. High graduation rates were reported.

The next case study is about the idea of networking. The Centre for Distance Education at Oldenburg University was able to develop with some minor initial funding a number of study guides for further training of nurses. The content must have hit the mark since nurses enrolled and paid for the course (still unusual in Germany) even without receiving any formal certificate. Moreover, a number of universities became interested. Leasing the course to those partner institutions (who would provide for the course presentation) for a fee only marginally above the production cost of the course material, the Centre for Distance Education was able to generate an income stream which was invested in continuously updating and adaptation of the course. The idea to outsource the course presentation allowed to keep the costs for the Centre for Distance Education in Oldenburg at a minimum.

Anglia Polytechnic University (APU) is based in East Anglia and achieved university status in 1992. It is developing a variety of approaches to open learning alongside its conventional teaching. APU worked with us on several case studies, one of which, on health and social welfare is reported here. It must be regarded as a pilot project and was not intended to be cost-efficient in the sense of getting low average costs. Our aim was to estimate the cost per student learning hour of the various media used in the interest of comparisons between them.

The French case refers to a consortium. The Centre de Télé-enseignement Universitaire (CTU) of the University of Rheims is part of the FIT-EST (or Féderation Universitaire d'Est). There is some division of labour between the participating universities in the sense that each centre specialises, within this programme, in teaching a specific subject area. Rheims deals with philosophy and psychology. The budget arrangements are different from most of those we encountered. There is no specific budget for course development. Instead, staff are seconded to the Distance Teaching Centre and freed from teaching duties on the understanding that they will produce a certain amount of resource material, which uses print and audio. Student support is limited to the marking of assignments. The system could in principle accommodate many more students and so reduce average costs.

The Politecnico di Milano in Italy has two faculties: engineering (30 000 students) and architecture (15 000 students). As the university expanded, a second campus was founded 40 km away in Como; videoconferencing is used to link the two. In the light of experience, the engineering faculty is developing an appropriate classroom design for teaching by means of videoconferencing. We were provided with data on the costs of delivering lectures by videoconferencing. The case study does not refer to a specific course but gives a more general discussion of the cost structure of videoconferencing, which is evaluated on the basis of the Milan data.

The Virtual Seminar is a co-operation between the University of Maryland in the United States and the Centre for Distance Teaching at the University of Oldenburg in Germany. The Centre for Distance Teaching is also linked with the Fernuniversität in Hagen, the biggest and best known provider of distance education in Germany. This arrangement allowed the Centre to launch its own initiative in international co-operation in setting up the Virtual Seminar. This is the only case study of a course which did not use print at all but was taught completely over the Internet. Average costs per student are high. However, since the target audience was a group of professionals working in institutions around the globe, it was argued that the costs should be compared with an international conference rather than with a course.

The Catalan Open University in Barcelona is still in a process of transition from being a print-based to a completely virtual institution. The University has been in operation only since 1995. It is a private university, but has the backing of the Catalan regional government, which brought together various regional institutions to support the new university. The university is intended to provide for the cultural and linguistic needs of the region. In the long run, it is proposed to use computer-based communication for all contact with students. However, up to the time of our data collection, course material was essentially print-based. It is assumed that changing from print-based provision to digitised provision over the Internet will reduce production and distribution costs significantly, but will entail high reception costs for the learner. It is suggested that such costs can be balanced by the savings for students in being able to study at home.

Basic information about the case studies appeared in table 1.1. (p. 11)

Conclusion

Throughout our research we sought to apply the methodology discussed in this chapter to this set of case studies. This makes it possible to move on and look at ways of applying our findings and turning them into a practical tool for the manager. There are, however, some practical differences of interpretation which we need to examine first. These are the theme of chapter three.

3 Why these things are difficult to interpret

Our work, and that of others, makes it possible to say how much different educational technologies are likely to cost, and how these costs will vary. But there are both conceptual and practical difficulties in applying these findings. We need to look at these before moving on.

Conceptual difficulties

We start with the problems inherent in any attempt to measure learning and go on to examine how far the costs of individual media can be separated out from each other in determining the cost per student learning hour. Finally, we comment on the conceptual problems of measuring the costs of individual media when using cost per student learning hour as our indicator.

Media and learning

Economists have argued that it is sometimes useful to treat education as a system in which you can optimise input/output relationships and develop an 'education production function' (Hanushek in Carnoy (ed.), 1995). The purpose of the approach is to facilitate comparison between measurable inputs to and outputs from the educational process. Following this approach we can try to examine how the input parameters affect performance in terms of outcomes, and seek to draw management guidelines from these calculations.

Changes in input parameters might, for example, include more books, better teacher training, and longer school hours. But it is not as simple as that. Educators rightly point out that results depend on what you do during these school hours, on the quality of the books, and on the content of the teacher training. The economic approach tends to disregard this: it is assumed that books, teacher training and other inputs live up to the standards of the educational requirements, and economic analysis does not require a qualitative appraisal.

Our approach resembles a production function in seeing media as machines which produce learning time with varying efficiency. Educators may quite properly object that learning effectiveness depends on how this time is used. There are, however, both practical and theoretical arguments for disregarding this qualitative issue. The practical arguments follow from the fact that we rarely have data that give us any information on the quality of learning or that relate this to a particular medium. The theoretical arguments follow from the assertion that, in the absence of evidence favouring one medium over another, it is reasonable to take the time spent in learning from any one medium as equivalent to learning from another. Thus we can with some legitimacy use a measure of learning time, and of the costs of the media used to provide it, as a proxy measure for cost-effectiveness. It is a better measure than anything else available.

Educators might further question if the study time created by each such machine is equivalent (as the media equivalence hypothesis suggests). It might be that learners' progress depends on individual differences in the style of learning or on the appropriateness of a medium for a particular task. We know that there are practical advantages for certain media which lead to their choice for particular functions. Recognition of objects, for example, can be triggered more swiftly by visual than by linguistic cues. (A detective will show around pictures to identify a suspect and not distribute descriptions. A scuba diving course will give divers an account of the fauna to be observed, using coloured identification charts, rather than lengthy descriptions.) This problem can be seen as the tension between the media equivalence hypothesis and the argument that media have different capabilities. We want to give this a new interpretation.

Education, as we know it, is predicated on written language. There is no science and no recorded literature before writing. Even academic oral language is based on writing. One reason for the fact that the choice of medium makes little or no difference to learning is that most media are able to communicate written language either as speech or as text. Written language is the great equaliser across the media. Furthermore, assessment is usually based on text. Learning which cannot be expressed in language is likely to be ignored in many tests or attempts to measure learning and finds little expression in effectiveness scores.

Almost all media make it possible to communicate conceptual language either in speech or in writing. A medium which cannot carry conceptual language does not qualify as educational medium. (A point in case are computer games: indeed children may learn a lot in computer games but much of what they learn is not measured by current assessment systems (Greenfield, 1984)). The 'no significant difference' findings (Russell, 1997) may flow, in part, from the fact that the experiments, like much education, ultimately depend on text.

The approach we propose is not a production function approach, which would result in recommending a specific set of inputs (a particular combination of media, in our case) to be favoured over the others. What we advocate is a framework, which identifies media, and examines their efficiency in creating learning time.

The conceptual difficulty here is to steer between ignoring effectiveness issues altogether (because they are too complex) and getting entangled in them (for the same reasons). In order to do this we have avoided any attempt to link the choice of medium directly to outcomes. As we have seen, without costly and lengthy research, that attempted to compare combinations of media rather than single media, and to do so in the field rather than the laboratory, we have no grounds for arguing that particular combinations are likely to increase or improve educational outputs. Instead, we have concentrated on costs, suggesting ways in which the manager can predict costs per student learning hour for a particular medium, and leaving as an educational decision the choice of medium for a particular task.

The framework of credit accumulation and transfer points (CAT points)

In concentrating on student learning hours we are encouraged by the fact that learning time is already used to measure achievement. In order to make degrees comparable across Europe a framework of credit accumulation and transfer is emerging. This associates degrees (and, by inference, their components) with time spent studying, in numbers of years, terms or semesters. It goes without saying that it is supposed that certain standards of quality are adhered to. But rather than attempting to compare a diversity of curricula, learning time is taken to provide the benchmarks. The credit accumulation and transfer scheme depends on a relationship between CAT points and student learning hours (SLH).

Table 3.1 indicates that the majority of institutions in England and Wales tend towards a ratio of ten SLH to one CAT point. (Negotiations about the acceptance of a universal framework of credit transfer and accumulation are still under way.)

Table 3.1: Number of learning hours corresponding to 120 CAT

Percentage of institutions (sample size=67)	10%	32%	54%
SLH per year (for FTE student)	1 080	900 - 960	1 200
SLH per week (over 30 weeks)	36	30	40

Source: based on HEQC; sample taken from institutions in England and Wales.

The relationship between CAT points and learning time assumes that general criteria of good practice are satisfied, and that the time spent with an institution is properly assessed. Given those conditions it demonstrates the willingness of institutions to treat student learning hours in practice as a proxy indicator to compare degrees and what they should refer to - achievements in learning.

Some difficulties do, however, remain. Not only is there still some variation in the agreed ratio between CAT points and learning time in different institutions across Europe, but there are also major differences in the provision made for the learning time, especially in terms of media support. In particular, within open and distance learning, there are big differences in the number of student learning hours supported by teaching media and the number allocated for individual work in which students are expected to study by themselves. Table 3.2 documents this. These differences have cost implications. Where course designers can present material in such a way that students need no mediated guidance for most of the time they are studying then, other things being equal, the cost of a teaching package will be much lower than one where such guidance is offered for nearly all the designated hours.

Table 3.2: Media-supported learning time as proportion of learning time

Course	SLH (Course)[a]	SLH (Media)[b]	Ratio	Percentage[c]
OUUK: Health and social welfare	220	135	1.6	61%
OUUK: Mathematics	448	306	1.5	68%
NKS: Post secondary adult education	418	88	4.8	21%
NKS: Teacher education	700	103	6.8	15%
APU: Health and social welfare	200	47	4.2	24%
CTU-Rheims: Philosophy	600	315	1.9	53%
IOE Advanced Diploma[d]	600	120[e]	5.0	20%

Source: own case studies; Notes: a: student learning hour per course; b: student learning hours provided for by study material or contact hours; c: percentage of media input as proportion of student learning hours stipulated for the course as a whole; d: half of an Advanced Diploma (120 CAT); e: contact hours.

Print: providing the integrating script

In calculating the costs of course development we need to decide how to attribute costs to the different media used. We encounter both conceptual and practical difficulties in doing this.

The conceptual difficulties arise from the role of the written language in education. As we saw, the development of text (whether delivered to the learner in print or on screen) has a central role in teaching. It provides the script, which integrates all other media, with the result that it is difficult to attribute the costs of preparing the basic text among the various media used, except in a quite arbitrary way. In our research we found it easier to identify costs for all other media than for print. This was sometimes due to accounting practice, which in some cases simulates an internal market between the different departments of an institution, so that the computer or media departments charge for their services to develop software or make a film while there is seldom a comparable charge for academic staff time in preparing text. Activity costing, which might yield useful data, is seldom yet in place.

The resulting difficulty in attributing costs varies from case to case. In the case of Anglia Polytechnic University (included in the case studies in part II) it has been comparatively simple: a printed document was re-edited for the Internet to include hypertext links as well as computer-aided learning devices and it was possible to derive figures for the cost of adaptation. A full accounting would, however, need to include figures for original writing and for design costs. These figures would also depend on the extent the design was carried over from the print to the screen. Uncertainties like this contribute to the possible margins of error of the cost figures.

In some cases we did not attempt to calculate the cost per student learning hour for print as the costs for staff time could not easily be attributed to different media. The figures for other media are likely to be on the low side as academic staff time may have been attributed to course development generally, and therefore included in the print cost, and possibly underestimated for television and CD-ROM components.

The attribution of learning time to media is also difficult. In practice other media are blended in; a student reading a module may be asked to listen to an audiocassette in order to answer questions arising from the text. Breaking down student time between reading and listening is then inevitably arbitrary.

Despite these difficulties of detail, there are such stark differences in the cost per student learning hour of different media that benchmarks, suggesting the order of costs to be expected, are of very great value in selecting media and planning a course.

CD-ROM: the problem of interactivity

It is particularly difficult to analyse the costs of CD-ROM. The low replication cost of a disc means that they are often produced without being loaded to capacity. This implies that the mere reference to a disc gives us hardly any useful information about the number of student learning hours to be attributed to it. Also the number of bytes may not provide the information needed to estimate learning time. (A colour photograph recognised in an instant needs more memory than a sizeable amount of print equivalent to many hours of reading.) Accounting for learning time and also accounting for costs requires a more detailed account about what is on the CD and about the processes involved in producing it.

At the simplest level some CD-ROMs contain text together with hyperlinks. Our studies have shown that about six hyperlinks can be incorporated into a text and tested in one hour. Computer-aided learning requires much more expenditure on staff time. A mid-point figure observed for designing computer-aided learning features like computer-marked multiple-choice questions is £10 000 per student learning hour. The design costs for more sophisticated development vary considerably; further costs are incurred, for example, when film clips are included.

We can then estimate the amount of time which the learner might spend on each specific feature. Such estimates are, however, partly normative and driven by the course designers' intention. In other words, we have the data to show how long course-designers expect students to spend on a particular activity but rarely have any information on the actual time spent. Learners generally confirm that interactive features slow the pace of their studies.

Design features in CD-ROM are often promoted as increased quality. In terms of raising effectiveness scores with respect to a set of curriculum objectives it is unlikely that they are always of measurable advantage, even if they enrich the learning experience.

It seems that CD-ROM is a case where educational technology induces some pressure to raise quality, rather than to reduce costs.

Computer-mediated communication: difficulties in attributing learning time

Computer-mediated communication can be used both as a resource medium - presenting teaching to students and as a communication - allowing asynchronous communication. Whereas videoconferencing tries to emulate seminar teaching or the traditional lecture, the asynchronous character of CMC puts it into a different category. At the same time it shares with videoconferencing the capacity to be used for open-ended teaching rather than to present pre-prepared resource material. As a result, we cannot simply estimate the cost per learning hour for CMC as a resource medium, without taking account of its role as a communication medium. Where CMC is used as a resource medium to deliver instructional content, we can investigate the costs incurred in making material available in digitised form. Generally, however, it is very difficult to estimate the number of student learning hours attributable to a CMC course component.

The Virtual Seminar, run between Germany and America, which used CMC, poses questions of this kind. One might attempt in theory to estimate the cost per student learning hour by looking at word counts, decide on a notional writing and reading time and estimate the average student learning hour from here. However, there is some evidence that students do not pay much attention to the messages of their peers, so that we are left with a measure that is partial as well as arbitrary. In practice there are no reliable research data yet which would allow us to specify the number of student learning hours attributable to one hour of CMC input by a tutor. In this case, therefore, we have not tried to estimate the student learning time in a bottom up way, based on word counts, but have based our estimates top down, using the student learning hour requirements indicated by the course designers.

Where CMC is used to enable communication with students it poses management as well as costing problems. The potential for external interactivity can lead to an explosion of tutor - student communication not anticipated in the budget. Policy guidelines for tutors and students may have to be issued to scale down expectations. It may not be feasible for an institution, or an individual, to meet the costs in money or time for all the interaction made possible. This can be seen as a disappointing effect: technology has facilitated communication to an unprecedented extent only to limit it again for economic reasons. From an economic standpoint communication technologies are a mixed blessing in so far as they facilitate external interactivity. They link teachers and students, with potential educational benefits, but by increasing the amount of tutorial time used in this interactive way they shift the balance of fixed and variable costs back towards variable costs, thereby eroding the economies of scale.

Video-conferencing: how to account for reduction in opportunity costs

Many costing decisions turn on departmental or institutional priorities: there may be a case for using open and distance learning if it costs less than conventional education or reaches a new audience. But, in calculating costs, we may need to consider costs that fall outside the institution as well as those within. Videoconferencing provides an example. We found that, in the cases we examined, videoconferencing was likely to cost the teaching institution more than conventional lecturing. But this conclusion omits the question of costs falling on the student. If videoconferencing makes it possible to deliver teaching to a remote student, reducing the time and costs for the student to travel to attend a lecture, then there may be real reductions in the cost to the student even while there are increased costs to the institution. We did not examine the opportunity costs of student time in any detail. They are, however, likely to be significant in the use of open and distance learning for professional and continuing education and for job-related training. The National Technological University, in the United States, for example, provides courses by videoconferencing using a satellite link to feed teaching into its postgraduate students' place of work. Its cost per student tends to be higher than the cost of conventional classroom teaching. But, if we take account of the opportunity costs of students' time - the amount they save by not travelling to a distant location - then its costs are likely to be lower than those of a conventional alternative (cf. Bih jen Fwu *et al.*, 1992)

Costing difficulties

We face a number of difficulties in calculating or estimating the costs of media.

Overheads

The costing of courses is based on the assumption that we can distinguish between institutional overheads and costs that can directly be attributed to a course. In practice this is seldom straightforward.

If we want to calculate the full cost of a course, we need to take account of overheads for such items as administration, accommodation, and the other general costs of running an institution. There are two difficulties in doing so. First, few institutions have embraced activity costing to the extent that they can attribute all overhead costs in a way that makes it possible to calculate these for a single course. It is, therefore, an arbitrary exercise, but may well seem pointless for a manager to define overheads for a particular course. More often, costs, such as the choice of media for a given course, are regarded as sunk costs, i.e. as irrelevant to the decision being taken, so that the analysis is taken no further. The second difficulty is that institutions vary in the way they treat overheads. While each institution's approach may suit its purpose, this makes comparisons between institutions more difficult. We have, in our work, generally accepted the way in which each institution calculates overheads, while recognising that this introduces an element of uncertainty into comparisons between institutions.

We need to take account of the issue of overheads both in comparing the costs of different approaches to open and distance learning and in comparing open and distance learning with conventional education.

If we want to compare the average cost per student in open and distance learning with that of conventional education, we need to calculate the cost per hour of lecturing in the conventional system. This brings in one further complication. The calculation depends both on the treatment of overheads and on the attribution of costs to teaching and research. Where staff are required to undertake both teaching and research we need to decide how much of their time (and therefore the cost of employing them) should be attributed to each. The research commitment in English universities, for example, is currently reported as ranging from 35% to 50%. Thus we may need to consider three sets of figures in order to calculate the cost of staff time: gross payroll figures, which will include superannuation and social security payments as well as basic salary, institutional overheads, and the proportion of time to be allocated for teaching rather than for research. To illustrate the effect of these on costs, some universities charge an overhead rate of 40% over gross payroll costs for consultancy work while the British Committee of Vice-Chancellors and Principals recommends the use of a manpower rate to cover all items which raises payroll costs by 105% (CVCP 1988).

Our treatment of overheads in general is a result of the practicalities of institutional research: there is no other realistic option than to base one's calculation on the data provided. The extent to which overheads are costed with any rigour varies widely between institutions and the basis on which overheads are calculated is in some cases unclear. We therefore need to be cautious in comparing data from different institutions; comparisons within any one institution are likely to be more robust.

Annualisation

In costing we always need to take account of both capital and recurrent expenditure. In the context of distance education considerable up-front capital investment is often required both for staff time in preparing teaching materials and for equipment. Videoconferencing provides one example. Let us assume that it requires altogether a capital investment of £80 000. Generally these costs are to be attributed across the lifetime of the system so that we need to calculate the cost per annum of the capital investment across that period. If we assume a lifetime of five years and a usage rate of 1 300 hours per year, we could simply divide the initial amount of £80 000 by the lifetime of the equipment getting a cost of £16 000 per year.

> With 1 300 hours of use we then get a cost per hour of:
> £16 000/1 300 = £12.

In this case we assume that each year we consume a fifth of the value of the system. But this calculation may under-estimate the cost. In each year we could, notionally, have put the money to an alternative use. We can estimate the return that we might have received on it if we had left it on deposit and gained the interest. Each year therefore we forgo not only the depreciated amount but also the interest, which would be gained up to then. This can be accounted for by an annualisation factor, which integrates the number of years and the interest rate. The formula is the following:

Equation 3.1:

$$a(r,n) = \frac{r \text{ x } (1+ r)^n}{(1+r)^n - 1}$$

The table 3.3 indicates the difference between the depreciated and the annualised capital at different interest rate over five years.

Thus the cost per hour, for 1300 hours use each year, rises from £12 if we ignore annualisation (or treat the interest rate as zero) to £15 at a rate of 7.5%, £16 at 10% and £18 at 15%.

Table 3.3: Annualisation of capital

Various interest rates interest at	r = 0.075 7.5%	r = 0.10 10%	r = 0.15 15%
Capital cost of videoconferencing system	80 000	80 000	80 000
Obsolescence time of equipment	5	5	5
Annualisation factor	0.247	0.264	0.298
Depreciated capital	16 000	16 000	16 000
Annualised capital	19 760	21 120	23 840

The significance of these calculations depends on the standpoint of the person doing the analysis. If you are an educational manager, concerned only with the problems of raising capital for a particular development, which is treated as sunk, and of meeting your recurrent costs, then you will be concerned with locating the initial £80 000 and not with a notional cost per annum derived from annualising it over a period of years. Educational managers can seldom in practice choose between using their allocated capital expenditure and investing it in order to get a good return. At a higher level of decision making, however, you may be interested in a full comparison between the costs of a capital-intensive or labour-intensive approach to education so that these calculations become less hypothetical. And if, as an educational planner, you want to compare the long-term effects of conventional and unconventional approaches to education, it is necessary to be sensitive to the cost, over the years, of the capital investment needed for each approach. Where large institutions are investing, say, sums of £500 000 or £1 million in course development, then the annual cost of the capital for this becomes a significant item.

Costs of writing and designing teaching materials

The difficulties we encountered in determining the cost of writing and designing print material illustrate some of the costing problems. We wanted to find out how much it cost to write materials and how much was then involved in editing and design. In practice, the different ways in which institutions keep their financial records and attribute time illustrates the difficulty in making comparisons between institutions. Table 3.4 illustrates this.

In three cases - at the Open University and CTU Rheims - we could not separate out print and design costs. In the case of the Open University it is argued that figures based on the costs of full-time staff might overestimate the costs, because of the level of overhead charges attributed to them,

and we have taken the costs for external authors instead. In the case of Rheims, the only information available was for hours of staff time, which could not be broken down further.

In other cases the level of detail differed considerably. In some we were given figures representing author-related costs and design costs. In others the only information available was the fee paid to an author with all other costs included in a single figure for print development. The uncertainty inherent in the figures makes it difficult to reach robust conclusions about the comparative costs of writing and of design.

Table 3.4: Relation of author and design related cost in print development

Currency: Sterling

	Writing cost per unit	Design cost per unit	Total	Ratio of writing to design cost
OUUK Social sciences	1 200	1 175	2 375	1.0
OUUK Mathematics	1 200	1 199	2 399	1.0
NKS Norsk	1 401	249	1 650	5.6
NKS Barnehagen	5 785	1 988	7 743	3.0
FVL Engineering	1 520	1 520	3 040	1.0
APU Nursing	667	725	1 392	1.0
CTU Reims Philosophy			2 196	
UOC Law	1 005	2 345	3 350	0.4

Source: own case studies

Practical difficulties

Alongside the conceptual difficulties and technical difficulties of costing, we had to overcome a number of practical difficulties which arose from the sensitivity of data and the pressures on staff time.

There is a new tension between co-operation and competition in higher education. The rising costs of higher education have induced governments to demand efficiency gains. Higher education institutions are compared with each other with respect to cost per student and, to a lesser extent, cost per graduate. This leads to an understandable caution in releasing sensitive information about costs. At the same time, some academic staff see open and distance learning as a job threat because of the expectation that it may be adopted as a cost-saving measure.

On the other hand there is a public demand for institutions to share experiences, in order to improve overall efficiency, and there are some institutional pressures to do this. Consequently, our experience was mixed, with occasional reluctance to release details about costs in spite of agreed co-operation in principle. (The problem is by no means a personal one. On a personal level co-operation generally was conducted in an amicable atmosphere. However, there was a considerable degree of inhibition about making data publicly accessible.) These problems could, to some extent, be avoided if one agreed to publish the data without reference to any specific institutions. We rejected this approach, mainly because an understanding of the context is necessary for a full understanding and interpretation of figures. (Anonymity is, in any case, sometimes difficult to achieve: it would be a bit transparent to refer to a large, English-speaking, open university within the European Union.)

Many academic and administrative staff are under pressure. There is little motivation to try to introduce an ignorant outsider into the intricacies of the organisation and its way of costing. Institutions use quite different methods, which defy the template a researcher might want to impose. There is one more difficulty here - a general scepticism about the usefulness of enquiries into cost effectiveness. It may be twofold, reflecting both a concern for job security and a practical conviction that academic staff want to get on with the job of teaching rather than concentrating on funding questions.

Conclusion

These conceptual and practical difficulties influence the way we carried out our work. They need to be borne in mind as a set of limiting factors on the robustness and generalisability of our findings. But, while it is necessary and proper to set them out, they do not prevent our making use of both our cost findings and the methodology we adopted. We look next at the practicalities of applying what we found.

4 How to apply it

The purpose of this chapter is to help make decisions about the choice of media for open and distance learning by applying the information and methods discussed so far. To do this we need to start with the benchmark cost data (table 1.2 to 1.5) and our understanding of the advantages and drawbacks of the different media available (tables 2.2 and 2.3). In doing so we need to consider the complementary roles of the course designer and the course manager (roles which may be combined in the same person). We can then look at the different stages of costing:

> Decide how many student learning hours will be allocated to the available resource media in order to calculate their development costs.
>
> Estimate the variable costs that will follow from this decision (e.g. the forecast production and distribution costs for a particular medium).
>
> Determine the cost of student support, another variable cost.

All these figures can be brought together in one spreadsheet. This allows rapid cost forecasting and makes it possible to see the effects of changing our choice of media.

To put this discussion in context we then look at the cost of conventional teaching. Its cost structure provides a point of comparison by which to gauge the efficiency achievable with different choices of media. The chapter ends with a discussion of the kind of information and decisions needed in designing a course or programme that will be cost-effective.

Managers and educators

A major problem in addressing issues of cost-effectiveness is a cultural divide between managers and educators. Educators generally are more interested in quality and effectiveness and tend to consider economic issues as something outside their main area of concern (Coopers and Lybrand, 1996). In contrast, managers are more likely to be concerned with the allocation and use of resources and their costs. Table 4.1 lists some aspects of this difference. The manager needs to decide in the face of considerable contingencies, so that management decisions need to operate on a more abstract level in the interest of flexibility. We have argued that cost per learning hour is a suitable management tool which can guide cost-effectiveness decisions.

Table 4.1: Managers and educators: different roles

	Manager/ administrator	Educator/ course designer
Focus of interest	Costs (inputs)	Academic achievement (outcomes)
Task and time orientation	Planning for the future	Implementation in the present
Level of attention	Attention to abstract structures	Attention to concrete details

Many educators have seen cost-effectiveness analysis as a method for research or evaluation rather than for academic planning. One tradition of research has involved investigating the choice of media in relation to their likely outcomes; educators have wanted to know how far a particular medium is likely to influence outcomes, whether measured in achievement scores or course completion rates. But, as we have already argued, comparison is seldom easy. While, in a good experimental situation, one would change educational strategies while keeping all other variables the same, this is seldom if ever possible when we are collecting field data. In our case we drew cost data from a widely differing set of environments - from the use of print and videocassettes for the inservice education of primary-school teachers in Norway to the use of the Internet for international professional education. We were encouraged in using this data by our desire to look at cost-effectiveness from a managerial point of view; which drove us to our concentration on cost per student learning hour.

From the educator's perspective the indicator of cost per student learning hour appears to be crude. In this section our aim is to show how the exchange between course designer (leaning more towards the educator’s position) and course manager could become a process which would improve cost-effectiveness. It is a process in which pedagogic requirements can be taken into account while at the same time their cost implications are kept visible.

Estimating the costs of media choice

To estimate the costs of media for a particular course we start by asking how the planned number of student learning hours will be allocated to each of the different media available. Here pedagogical considerations can play a part: we have to balance one-way presentation of content and active engagement by the learner. This kind of engagement can be achieved by means of either internal or external interactivity. We need then to look separately at the costs of resource media and of communication media, and go on to identify fixed and variable costs. These make it possible to evaluate the total and average cost functions for any level of enrolment.

Distributing student learning time

Before a course is planned in detail, decisions are needed about its length and level which together determine the number of student learning hours. These decisions are often outside the control of an individual course manager or course writer. The designated number of student learning hours, required to teach the subject matter, set the upper boundary for the number of hours to be allocated to media; some hours are likely to be attributed to individual, private, work by the student which has no cost implications for the teaching institution.

In chapter two we presented two tables, which provide a possible format for the distribution of student learning hours against the different media (tables 2.2. and 2.3). Table 2.2 lists the media (breaking down the features of computer-based teaching) against the headings of presentation, internal and external interactivity. The shaded areas indicate the media (horizontal entries), which have particular advantages for a given teaching feature (vertical entries). Its layout allows us to monitor the balance between one-way instruction (presentation of content) and more active learning features. The distribution of the shading suggests, for example, the strengths of computer media to support internal interactivity. Several formats to link media capabilities to teaching functions have been proposed (Laurillard, 1993); a simple version is presented in table 2.3. The point here is not to advocate one specific format but to argue that in the process of media selection such formats can facilitate a monitoring process (e.g. by indicating the proportions of learning time devoted to the presentation of teaching material and to dialogue among students or with tutors) and keep the media options visible.

In both tables (table 2.2 and 2.3) the horizontal subtotals (summarised in the last column to the right) are important for the next step. By showing the amount of time allocated to each medium they provide the starting points for costing the inputs of both resource media and communication media.

Calculating the resource-medium costs

In order to calculate cost per student learning hour for resource media, medium by medium, we need to take account of both their fixed costs - often predominantly development costs - and the variable costs that follow from the choice of any one medium. We know for instance that the choice between television and videocassettes depends partly on the variable cost that is incurred for each student if videocassettes have to be manufactured and distributed. The higher development cost per student learning hour of broadcast television may be outweighed by its lack of variable costs, and insensitivity to increasing student numbers (A.W. Bates, 1995).

In table 4.2 we set out some exemplary costs for the resource media used in a notional course, using print, radio and some computer-based teaching. The actual figures used are indicative, and

are based on our case studies. These are all fixed costs, for the development of teaching to provide the number of student learning hours shown against each medium.

Table 4.2: Ready reckoner for resource media Currency: Sterling

Resource media	Student learning hours	Unit equivalents	Cost per unit	Fixed costs
	SLH	UE	Cost/UE	£
Print	150	15[h]	3 500	52 500
Radio	1	1	20 000	20 000
Television	0	0	120 000	0
Audio	0	0	1 700	0
Video	0	0	35 000	0
Computer-based teaching				
Hypertext[a]	20	20	700	14 000
Computer-marked assignments (CMA)[b]	5	5	100	500
Interactive CMA[c]	20	20	1 100	22 000
Computer tools[d]	0	0	250	0
Computer-searchable databases[e]	0	0	150	0
Computer-assisted learning (CAL)[f]	0	0	11 500	0
Multi media CAL[g]	15	15	12 000	180 000
Total	211			289 000

Notes: a: a text document with links to other text documents; b: generally in multiple-choice format and used mainly for tests; c: the program evaluates the learner's response and may then present new questions or hints about solutions to a problem; d: generally involving the use of software (e.g. spreadsheets) available on the market; e: often using generic software; copyright often needs to be cleared for documents included within the database; f: an umbrella term for interactive approaches which vary widely in their complexity; g: likely to include sounds and film clips, thus incurring designs as well as programming costs; h: 1 UE print = 50 pages = 5 SLH

We can now go on to incorporate into our planning the variable costs that will follow from our decision to choose a particular teaching medium. In order to do this we have translated the number of student learning hours into units (or unit equivalents, UE) specific for each medium. The UE for print is defined as 50 pages of print and is taken as providing for ten student learning hours; the unit equivalents for cassettes are C60 and cassettes. The unit equivalent for learning resources

delivered on CD-ROM is a disc. If we know the number of these unit equivalents it is possible to calculate the variable cost per student, as shown in table 4.3.

The costs we use for reproduction and distribution of the respective unit equivalents are necessarily crude: a student learning hour of audiocassette can, for example, be provided as one C60 or two C30 cassettes. If data are integrated in a spreadsheet, modifications to take account of actual or changing costs are easily made. The point here is not to demonstrate actual cost but to prepare a spreadsheet, which allows customisation to different contexts.

Table 4.3: Ready reckoner for the induced variable costs Currency: Sterling

Resource media			Variable cost per student of Replication		Distribution		Total
	SLH	UE	Cost/UE	Total	Cost/UE	Total	
Print	150	15	1.00	15.00	0.50	7.50	22.50
Radio	0	0					
Television	0	0					
Audio	0	0	1.00	0	1.00	0	0
Video	0	0	2.50	0	2.00	0	0
Computer-based teaching							
Hypertext	10	10					
Computer-marked assignments (CMA)	5	5					
Interactive CMA	20	20					
Computer tools	0	0					
Computer-searchable databases	0	0					
Computer-assisted learning (CAL)	0	0					
Multi media CAL	15	15					
CD-ROM (Subtotal)		1	3.00	3.00	1.00	3.00	4.00
Total							26.50

Source: own case studies

Calculating the communication-medium costs

We need a different approach in considering the cost of communication media. Here we are less concerned with the cost per student learning hour than with the cost, of providing for interaction

with the student, that falls on the institution. In examining tutorial costs, for example, the educational manager needs to know how much time will be spent by the tutor, and so the size of the bill for tutors' pay, and is less concerned with the amount of time spent by the student. For this reason we suggest that the manager should develop a set of unit equivalent costs for communication media. In table 4.4 we set out some exemplary costs. We need to take account of three elements in calculating these unit costs. First, the cost of tutorial time which we can assume will be at the same hourly rate regardless of the medium used. Second, for electronic media like telephone-based teaching or videoconferencing, we may have equipment costs and line charges. Third, we may need to consider how face-to-face tutoring is provided. With the exception of the marking of assignments, student support is often provided to groups of students rather than to individuals so that, to derive a unit cost, we need to divide the total cost by the average number of students in a group.

Table 4.4: Ready reckoner for unit cost contribution of communication media

Currency: Sterling

Communication media	Unit equivalents (UE) of inputs	No of UE	Cost/ UE	Formula and unit costs (i.e. variable cost per student)	Total unit cost contribution
Computer-mediated communication	Hour of tutorial time	5	25.00	$\frac{\text{cost/UE}}{\text{group size}} = \frac{£25}{20} = £1.25$	6.25
Video-conferencing	Hour of staff, depreciated equipment, line time	1	160.00	$\frac{\text{cost/UE}}{\text{group size}} = \frac{£160}{20} = £8$	8.00
Telephony	Fraction of tutor time and line time	1	8.00	$\frac{\text{cost/UE}}{\text{group size}} = \frac{£8}{20} = £0.4$	8.00
Tutorials	Hour of tutorial time	8	25.00	$\frac{\text{cost/UE}}{\text{group size}} = \frac{£25}{20} = £1.25$	10.00
Tutor-marked assignments	Assignment marked	4	12.00	Cost/UE =£ 12	48.00
Total					80.25

Table 4.4 summarises decisions on the amounts of communication media and sets out the unit cost calculated for each medium as a consequence of these decisions. The total variable costs for staff support have to be added to the variable costs of the resource media in order to complete the picture

of the costs for a given course. The example presented in tables 4.3 and 4.4 gives us a total variable cost of £106.75 made up of £26.50 for the cost for resource media and £80.25 for communication media and student support.

Putting it all together

From tables 4.2 to 4.4 we can now calculate the total and average costs for different levels of enrolment. Table 4.5 puts the data together and calculates the costs for different levels of enrolment.

Table 4.5: Total and average costs for different levels of enrolment Currency: Sterling

		Level of enrolment		
	Cost functions	Low	Medium	High
Student number		1 000	5 000	10 000
Total cost function				
TC = F + V x s	TC=289 000+106.75 x s	395 750	822 750	1 356 500
Average cost				
AC = F/s +V	AC=(289 000/s)+106.75	396	165	136

We will integrate all the different tables (table 4.3 to 4.4) in a unified spreadsheet (see table 4.6), which easily allows modification and keeps the cost dimension visible during the process of media selection.

Table: 4.6: A simplified spreadsheet

	Student learning hours	Unit equi valents	Cost per unit	Fixed costs	Variable cost per student of			Total unit costs
					communication	production	distribution	
Resource media	SLH	UE	per UE	£		£	£	£
Print	150	15	3500	52500		1,0	0,5	22,5
Radio	0	0	20000	0				
Television	2	2	120000	240000				
Audio	5	5	1700	8500		1,0	1,0	10,0
Video	12	12	35000	420000		2,5	2,0	54,0
Computer-based teaching								
Hypertext	20	20	700	14000				
Computer-marked assignments (CMA)	4	4	100	400				
Interactive CMA	6	6	1100	6600				
Computer tools	20	20	250	5000				
Computer-searchable databases	15	15	150	2250				
Computer-assisted learning (CAL)	7	7	11500	80500				
Multi media CAL	3	3	12000	36000				
CD-ROM (Subtotal)	75	2				3,0	1,0	8,0
Communication media			per hour					
Computer-mediated communication	12	12	25,0		15,0			
Videoconferencing	3	3	160,0		6,0			
Tutorials	8	8	25,0		10,0			
Tutor-marked assignments	40	4	12,0		48,0			
Unit cost (Subtotals)					79,0	7,5	4,5	94,5
Total	307			**865750**				**173.5**

	enrolment level:	low	medium	high
Students		1000	5000	10000
Total costs		1039250	1733250	2600750
Average costs		**1039**	**347**	**260**

Modifying the media selection

Media selection can be an iterative process. A first plan of a course is drafted and its cost estimated. Modifications are made and their cost implications estimated. For this purpose a spreadsheet, which integrates the information collected on cost per student learning hour of resource media, their variable costs, and the unit costs for communication media, is helpful in facilitating a rapid cost appraisal.

Table 4.6 represents such a spreadsheet. It integrates the tables (4.2 to 4.5) and feeds the results into an equation of total and average costs.

Table 4.6 uses all media and includes a variety of different types of computer-based teaching, purely as an illustration. Such a wide choice is highly unlikely in practice, not only because it leads to unsustainably high costs; we chose to include all media in order to make the working of the spreadsheet clear.

In looking at the distribution of rows in the spreadsheet we can see that the first set of rows shows the *resource media*. In the case of print, audio- and videocassettes we have both fixed costs of development and variable cost of reproduction and distribution. The fixed costs per learning hour (or cost per unit equivalent) are taken from table 4.2. Similarly, the unit cost of reproduction and distribution are taken from table 4.3. Television and radio have no variable cost per student. This applies also for computer-based teaching if it is made available over the Internet (downloading costs are marginal and neglected here; in this context we also chose to ignore reception costs).

We may also choose to distribute computer-based teaching material on CD-ROM. In this case variable costs are incurred. Our spreadsheet display indicates costs of digitised features in more detailed breakdown, in which case we have no fixed costs against the heading CD-ROM. Alternatively we may aggregate the digitised features and put a figure against CD-ROM. In each case we have unit costs for reproduction and distribution.

The second set of rows in table 4.6 relates to *communication media*, showing cost per hour of input rather than per hour of student learning time.

Looking next at the columns, we can see that the second column summarises the manager's allocation of student learning hours to particular media.

The third column shows student learning hours in unit equivalents on the lines discussed above (10 student learning hours print are shown as equivalent to 50 pages, which we treat as a unit (unit equivalent). The unit equivalents are packages of SLH which, in the case of resource media, correspond to material objects like books, tapes or discs. The production and distribution of such teaching materials generate variable costs. In all cases other than print and CD-ROM the unit equivalent is equal to a student learning hour. The unit equivalent of one student learning hour

audio is a C60 cassette. The reproduction and distribution costs relate to the cost of the cassette, the production cost of copying and the distribution costs. These costs are summarised in the last column.

The cost per unit column refers to cost per unit equivalent in the case of resource media and to cost per hour of input for communication media.

In the lower part of the spreadsheet student numbers can be entered, making it possible to calculate total as well as average costs. As an illustration we show total and average costs for low, medium and high enrolment for the given choice of media.

Application of the spreadsheet

Spreadsheets of this kind can be used for the rapid appraisal of costs and to estimate the consequences of changes to course design. We start by calculating a low cost option, which is used as default option. This is a print-based option, complemented by a minimum of support through tutor-marked assignments and face-to-face tutorials. The data on the costs of media suggest that this likely to be the most cost-effective option, provided we leave out of our calculation questions of motivation, and completion rates that may depend on it. Thus, this option is likely to be the least-cost option as measured in terms of cost per student. It may not be the least-cost option if we measure in terms of successful students.

As an example we consider a 30 CAT point course. We opt for a level of media support of about 200 to 250 SLH (including tutor-marked assignments). The course is entirely print-based with a minimum of face-to-face tuition (four sessions). Four assignments are required. The average cost is set against a projected enrolment of 1 000, 5 000 or 10 000 students. Table 4.7 sets out the costs for this option.

The spreadsheet allows us to instantly investigate variations: what will happen when we increase the standard student support, say from four to eight tutorials? The variable cost will increase from £83 to £88 and this in turn will increase average costs (for 5 000 students we see an increase from £97 to £102; table 4.8; *modification 1*). If we wanted to compensate for the four hours increase in tuition, we would have to double the enrolment; with 5 000 students and rather low fixed costs the scale economies are already largely exhausted.

In *modification 2* we have changed the choice of media, by introducing 15 hours of audio and 5 hours of video, something that might be appropriate for a language course. Print costs have been reduced slightly but tutorial costs maintained at 8 hours. The results are set out in table 4.9. With the increased fixed costs for audio and video, the cost per student more than doubles at an enrolment of 1 000. At the same time the high difference between the aggregated unit costs and the

average costs signal room for economies: raising the enrolment level to 5 000 we can cut average costs by more than a half.

Television can be a powerful means to advertise a course and perhaps increase enrolment. If two hours (or about six 20-minute slots) of television were introduced in place of the video component, the average costs would rise if the low enrolments were unchanged. But if the increased level of publicity doubled the enrolment to 2 000 over the lifetime of the course we would have an average cost level of £274 and would have compensated for the increased fixed cost of television (table 4.10; *modification 3*).

We can also look at the effect of introducing computer-based teaching rather than audio and video or television. In order to develop material to support 60 SLH with CD-ROMs we would need an investment of £216 500. As table 4.11; *modification 4*, shows this would give a relatively high average cost, at £391 per student with an enrolment of 1000 as compared with a figure of £153 for the default option. But there are potential economies of scale here: with an enrolment of 5000 (which might be spread over a number of years) the cost comes down to £160 per student compared with £97 for the default option. An educational as well as an economic judgement will be needed as to whether the increased cost over the default option is justifiable in terms of any increase in educational quality. (We said that quite often the number of CD-ROM discs is a matter of convenience rather than of the space available on them. If we could use only one instead of five discs we would end up with average costs reduced by more than £10.)

The discussion demonstrates the value of spreadsheet facilities to keep costs visible while discussing the media options. They could, of course, be much more detailed without being much more difficult to operate. Benchmark data to be included in them would need to be customised to fit the circumstances of a particular institution. The figures here are indicative (i.e. based on real world figures) but not necessarily representative (i.e. based on systematic sampling). But with a system of this kind the cost implications of media decisions can be at the manager's fingertips.

Table: 4.7: Default option (Print based)

	Student learning hours	Unit equi valents	Cost per unit	Fixed costs	Variable cost per student of			Total unit costs
					communication	production	distribution	
Resource media	SLH	UE	per UE	£		£	£	£
Print	200	20	3500	70000		1,0	0,5	30,0
Radio	0	0	20000	0				
Television	0	0	120000	0				
Audio	0	0	1700	0		1,0	1,0	0,0
Video	0	0	35000	0		2,5	2,0	0,0
Computer-based teaching								
Hypertext	0	0	700	0				
Computer-marked assignments (CMA)	0	0	100	0				
Interactive CMA	0	0	1100	0				
Computer tools	0	0	250	0				
Computer-searchable databases	0	0	150	0				
Computer-assisted learning (CAL)	0	0	11500	0				
Multi media CAL	0	0	12000	0				
CD-ROM (Subtotal)		0				3,0	1,0	0,0
Communication media			per hour					
Computer-mediated communication	0	0	25,0		0,0			
Videoconferencing	0	0	160,0		0,0			
Tutorials	4	4	25,0		5,0			
Tutor-marked assignments	40	4	12,0		48,0			
Unit cost (Subtotals)					53,0	7,5	4,5	30,0
Total	244			**70000**				**83**

	enrolment level:	low	medium	high
Students		1000	5000	10000
Total costs		153000	485000	900000
Average costs		**153**	**97**	**90**

Table: 4.8: Modification 1 (Increasing tutorial support)

	Student learning hours	Unit equi valents	Cost per unit	Fixed costs	Variable cost per student of			Total unit costs
					communication	production	distribution	
Resource media	SLH	UE	per UE	£		£	£	£
Print	200	20	3500	70000		1,0	0,5	30,0
Radio	0	0	20000	0				
Television	0	0	120000	0				
Audio	0	0	1700	0		1,0	1,0	0,0
Video	0	0	35000	0		2,5	2,0	0,0
Computer-based teaching								
Hypertext	0	0	700	0				
Computer-marked assignments (CMA)	0	0	100	0				
Interactive CMA	0	0	1100	0				
Computer tools	0	0	250	0				
Computer-searchable databases	0	0	150	0				
Computer-assisted learning (CAL)	0	0	11500	0				
Multi media CAL	0	0	12000	0				
CD-ROM (Subtotal)		0				3,0	1,0	0,0
Communication media			per hour					
Computer-mediated communication	0	0	25,0		0,0			
Videoconferencing	0	0	160,0		0,0			
Tutorials	8	8	25,0		10,0			
Tutor-marked assignments	40	4	12,0		48,0			
Unit cost (Subtotals)					58,0	7,5	4,5	30,0
Total	244			**70000**				**88.0**

	enrolment level:	low	medium	high
Students		1000	5000	10000
Total costs		158000	510000	950000
Average costs		**158**	**102**	**95**

Table: 4.9: Modification 2 (Introducing video and audio components)

	Student learning hours	Unit equi valents	Cost per unit	Fixed costs	Variable cost per student of			Total unit costs
					communication	production	distribution	
Resource media	SLH	UE	per UE	£		£	£	£
Print	180	18	3500	63000		1,0	0,5	27,0
Radio	0	0	20000	0				
Television	0	0	120000	0				
Audio	15	15	1700	25500		1,0	1,0	30,0
Video	5	5	35000	175000		2,5	2,0	22,5
Computer-based teaching								
Hypertext	0	0	700	0				
Computer-marked assignments (CMA)	0	0	100	0				
Interactive CMA	0	0	1100	0				
Computer tools	0	0	250	0				
Computer-searchable databases	0	0	150	0				
Computer-assisted learning (CAL)	0	0	11500	0				
Multi media CAL	0	0	12000	0				
CD-ROM (Subtotal)		0				3,0	1,0	0,0
Communication media			per hour					
Computer-mediated communication	0	0	25,0		0,0			
Videoconferencing	0	0	160,0		0,0			
Tutorials	8	8	25,0		10,0			
Tutor-marked assignments	40	4	12,0		48,0			
Unit cost (Subtotals)					58,0	7,5	4,5	79,5
Total	248			**263500**				**137,5**

	enrolment level:	low	medium	high
Students		1000	5000	10000
Total costs		401000	951000	1638500
Average costs		**401**	**190**	**164**

Table: 4.10: Modification 3 (Shifting to using television)

	Student learning hours	Unit equi valents	Cost per unit	Fixed costs	Variable cost per student of			Total unit costs
					communication	production	distribution	
Resource media	SLH	UE	per UE	£		£	£	£
Print	180	18	3500	63000		1,0	0,5	27,0
Radio	0	0	20000	0				
Television	2	2	120000	240000				
Audio	15	15	1700	25500		1,0	1,0	30,0
Video	0	0	35000	0		2,5	2,0	0,0
Computer-based teaching								
Hypertext	0	0	700	0				
Computer-marked assignments (CMA)	0	0	100	0				
Interactive CMA	0	0	1100	0				
Computer tools	0	0	250	0				
Computer-searchable databases	0	0	150	0				
Computer-assisted learning (CAL)	0	0	11500	0				
Multi media CAL	0	0	12000	0				
CD-ROM (Subtotal)		0				3,0	1,0	0,0
Communication media			per hour					
Computer-mediated communication	0	0	25,0		0,0			
Videoconferencing	0	0	160,0		0,0			
Tutorials	4	4	25,0		5,0			
Tutor-marked assignments	40	4	12,0		48,0			
Unit cost (Subtotals)					53,0	7,5	4,5	57,0
Total	241			**328500**				**110,0**

	enrolment level:	low	medium	high
Students		1000	5000	10000
Total costs		438500	878500	1428500
Average costs		**439**	**176**	**143**

Table: 4.11: Modification 4 (Using CBT components)

	Student learning hours	Unit equi valents	Cost per unit	Fixed costs	Variable cost per student of			Total unit costs
					communication	production	distribution	
Resource media	SLH	UE	per UE	£		£	£	£
Print	150	15	3500	52500		1,0	0,5	22,5
Radio	1	1	20000	20000				
Television	0	0	120000	0				
Audio	0	0	1700	0		1,0	1,0	0,0
Video	0	0	35000	0		2,5	2,0	0,0
Computer-based teaching								
Hypertext	20	20	700	14000				
Computer-marked assignments (CMA)	5	5	100	500				
Interactive CMA	20	20	1100	22000				
Computer tools	0	0	250	0				
Computer-searchable databases	0	0	150	0				
Computer-assisted learning (CAL)	0	0	11500	0				
Multi media CAL	15	15	12000	180000				
CD-ROM (Subtotal)	60	5		216500		3,0	1,0	20,0
Communication media			per hour					
Computer-mediated communication	5	5	25,0		6,3			
Videoconferencing	0	0	160,0		0,0			
Tutorials	4	4	25,0		5,0			
Tutor-marked assignments	40	4	12,0		48,0			
Unit cost (Subtotals)					59,3	7,5	4,5	42,5
Total	260			**289000**				**101,75**

	enrolment level:	low	medium	high
Students		1000	5000	10000
Total costs		390750	797750	1306500
Average costs		**391**	**160**	**131**

Comparing with lecturing

Institutions may have different benchmarks to assess their performance. At the institutional level, economic comparisons are usually made in terms of cost per student or cost per graduate. Policy makers and institutions are often interested in the comparative costs of open and distance learning and of conventional education. We can use the approach discussed so far to compare the cost structure of conventional lecturing with the default option calculated above.

In order to calculate the cost of conventional teaching we need to know the staffing cost, or cost per contact hour, the number of contact hours, and the number of students in a group. (In the following example we use the term 'lecturing' to cover both formal lectures and seminars or tutorials.) We assume that a lecture has to be repeated if the number of students exceeds a specified group size. Thus, if we set the maximum group size as twenty and have 155 students, it is necessary to repeat a class or lecture eight times. As a result the total cost for lecturing is the cost for each lecture multiplied by the number of lectures or contact hours in a series of classes, multiplied by the number of repetitions. This gives us the following equation:

$$\text{TC(Lecturing)} = (\text{lecturing cost per hour x contact hours}) \text{ x no of repetitions}$$

$$\text{where: no of repetitions} = \left[\frac{\text{students}}{\text{group size}} \right]$$

Therefore we have:

$$\text{TC(Lecturing)} = (\text{lecturing cost per hour x contact hours}) \text{ x} \left[\frac{\text{students}}{\text{group size}} \right]$$

In order to determine the average costs of lecturing we have to divide the total cost of lecturing by the number of students.

$$\text{AC(Lecturing)} = \frac{\text{TC(Lecturing)}}{\text{students}}$$

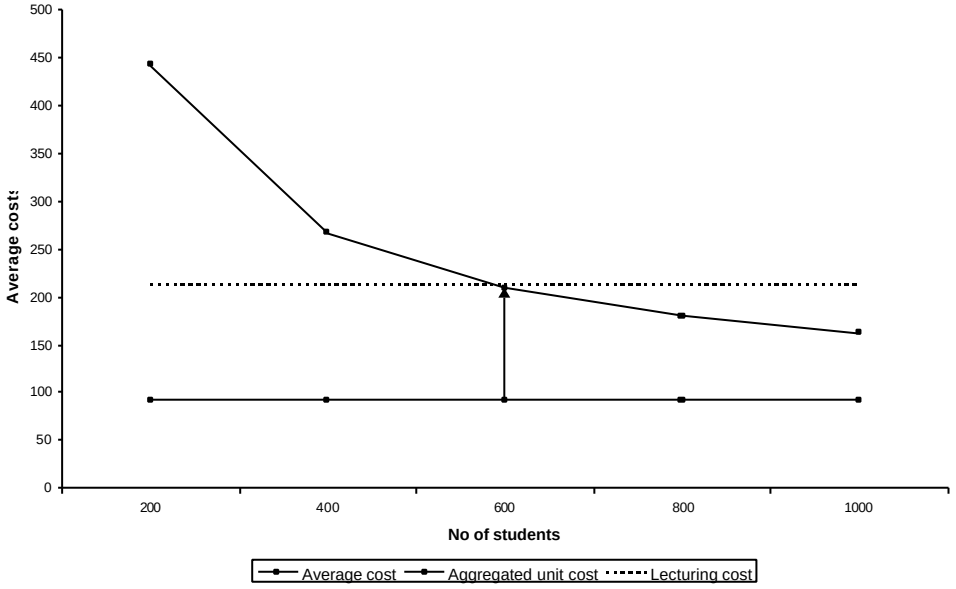
$$= \frac{(\text{lecturing cost per hour x contact hours}) \text{ x} \left[\frac{\text{students}}{\text{group size}} \right]}{\text{students}}$$

This leads to the final equation:

$$\text{AC(Lecturing)} = \frac{\text{lecturing cost per hour x contact hours}}{\text{group size}} = \text{constant}$$

This is an important observation. It means that if we identify the costs of conventional education with the costs of lecturing (an admitted simplification), then the representation of such costs as graphs are straight lines parallel to the x-axis: there are no economies of scale open to us. They are very much like the unit cost term in their graphic representation of the average cost of distance education courses. (While this holds true, there are two complications which we would need to bear in mind in making any real comparison. First, the group size for a lecture is likely to be greater than the group size for a seminar. One way of reducing the cost per student in conventional calculation is to shift the balance between lectures and seminars. Second, seminar group size is not fixed. Anecdotal evidence suggests that, in England for example, it has risen in recent years. This process has been described both as efficiency gain and as erosion of quality.)

Figure 4.1: Comparing DE with lecturing



Notes: average costs are in £; the arrow indicates the break-even point with lecturing.

Figure 4.1 represents the graph of the average cost function of a distance education course (AC = F/s +V). It drops down towards a line parallel to the x-axis. This line represents the constant term in the average cost function (i.e. the variable cost per student V). In other words, if the variable costs of open and distance learning (for such activities as reproducing and distributing course materials and providing tutorial support) are greater than the constant cost of enrolment.

If the lecturing costs are above this level but the difference is small, then we have to determine the break-even point. It may well be that the break-even point is beyond the probable level of enrolment.

We can now compare a default option with an alternative delivered conventionally. Since for the default option above we assumed a 30 CAT point course of 300 student learning hours, we do the same for the lecturing alternative. Some institutions have reported as a rule of thumb that 30 CAT points will be supported by 45 contact hours.

The acceptable group size for a seminar varies but to begin with we assume a group size of 15 students.

The cost of a lecturer per hour also varies between institutions and even more so between countries. However, since these variations are not the focus of discussion here, we base our comparison on the cost per hour of a senior lecturer on a mid-point in salary in higher education in England (1997). Even then there is some variation. Lecturers have teaching obligations and are required also to undertake research. As we saw, the cost per hour varies depending on the extent to which the research obligations are taken into account. Similarly the way in which overheads are to be taken into account varies. The table 4.12 indicates the resulting range of costs per hour.

If we take overheads into account at 40% but ignore research obligations and insert these data into the above formula, we get:

$$\text{AC(Lecturing)} = \frac{\text{lecturing cost per hour x contact hours}}{\text{group size}} \Rightarrow$$

$$\text{AC(Lecturing)} = \frac{£71 \text{ x } 45}{15} = £\ 213$$

Table 4.12: Cost of lecturing Currency: Sterling

Research considered at	Number of Hours	Plain Payroll (for £28 000 per year)	PP + 40% overheads (£39 200 per year)
		Per hour	Per hour
0%	550	51.00	71.00
35%	846	33.00	46.00
50%	1 100	25.00	36.00

Note: this table takes as its starting point the assumption in case study 7 that a lecturer teaches 550 hours a year and examines the effect on teaching costs about decisions to attribute costs entirely to teaching or partly to teaching and partly to research.

To compare lecturing with the default option for a distance education course we check first if the necessary condition for the greater efficiency of distance education is satisfied: The lecturing costs must be lower than the aggregated unit costs. Since 92 < 213, this condition is satisfied. Therefore it makes sense to determine the break-even point.

The break-even point is determined by finding the intersection point of the two respective graphs. Algebraically, we have to solve the equation AC(Lecturing) = AC(s) for s.

$$\text{AC(Lecturing)} = \text{AC(s)} \Rightarrow £\,214 = \frac{£\,70\,000}{s} + £\,92 \Rightarrow$$

$$£\,214 - £\,92 = \frac{£\,70\,000}{s} \Rightarrow £122 = \frac{£\,70\,000}{s} \Rightarrow$$

$$s = \frac{£\,70\,000}{£122} = 574$$

This means s = 574 is the break-even point: with more than 574 students enrolled the average cost of the distance teaching alternative provides lower average cost and can be said to be more cost-efficient. The arrow in figure 4.1 indicates the break- even point.

Next, we need to look at the effect of changing group size. Table 4.13 looks at the effect of changing group size on the break-even point between open and distance learning and lecturing.

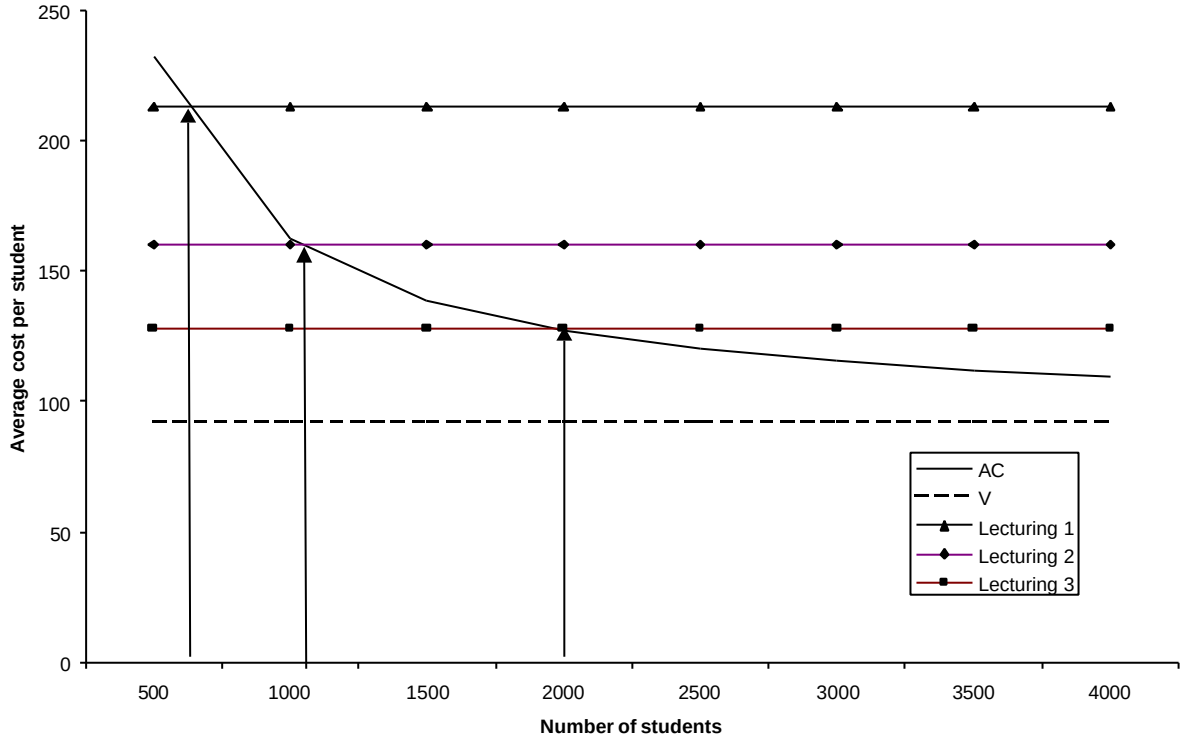
While increasing the class size has a considerable effect on the break-even points, in all cases the variable cost of our default option (print-based distance education) is competitive with lecturing. In all cases the necessary condition of potential cost-efficiency is satisfied: in all variations, the average cost per student of courses delivered by lecturing is above the variable cost per student of the distance-teaching option.

Table 4.13: A sensitivity analysis Currency: Sterling

Based on £46 as cost per hour per lecturer	Class size	Break- even point
AC Lecturing = 138	15	1 522
AC Lecturing = 104	20	5 833
AC Lecturing = 83	25	none

This is illustrated in Figure 4.2. The break-even points are indicated with arrows. The lower the average cost per lecturing, the further to the right is the break-even point. In this case they remain within the likely level of enrolment we have specified.

Figure 4.2: Sensitivity analysis



Information, calculation, decision

We can now summarise what information is needed in order to use cost-effectiveness analysis to help course planning and how the information can be used.

The manager needs two sets of basic information. The first set is derived from decisions about the scale, level and weighting of a course. We have suggested that the total number of student learning hours is likely to be the key variable here. The second set comprises information about the costs of different kinds of teaching. We have suggested that it is useful to develop a set of benchmark costs for the fixed and variable costs likely to be incurred for different media.

Next, critical decisions have to be taken about the breakdown of student learning hours between teaching that is provided by the institution, individual study time, and the amount of time to be allocated to resource media, providing instruction, and communication media, permitting dialogue.

Once this information is gathered and these decisions are taken, a number of inferences can be drawn about the costs to be expected for particular levels of enrolment and combinations of media. Table 4.14 sets out the parameters involved. The approach discussed in this chapter, and the kind of spreadsheets discussed, are designed to help in their examination and analysis.

Table 4.14: Relevant parameters

	Information required	Decision to be taken	Inferences to be made
No of SLH	X		
No SLH to be supported by media		X	
By resource media		X	
By communication media		X	
Costs per input			
Cost/SLH(resource medium)	X		
Unit cost/resource medium	X		
Cost/SLH(communication medium)	X		
Total costs			
Total fixed costs			X
Total unit costs			X
Student number	X		
Total costs			X
Average costs			X

5 How to justify your decisions

We have concentrated so far on the problem of media choice from the perspective of the course manager. We have looked at questions of quality and effectiveness, costs and efficiency, looking at the implications for planning a single course. When looking at costs, however, we concentrated on the costs incurred by the institutions and consequently ignored reception costs, which are generally costs to the learner. We now need to consider these costs and their implications for learners.

Access and reception costs

If we look at costs from an economist's point of view rather than the view of an educational manager inside an institution, we realise that costs are incurred at the point of reception. Traditionally these costs have been small (e.g. the cost of posting an assignment) or marginal (e.g. the cost of using the radio for listening to an educational programme). If you estimate the depreciated cost of a television set for the length of time when it is used for educational purposes, the reception costs to the learner are indeed marginal. Radio and television sets are part of the standard equipment of a household in a developed country: 98% of British households have television and 81% have a phone.

There is a clear threshold in the transition to computer-based learning. Up to that point, it could be argued that no extra costs are incurred to the learner in using communication technology, for education as radio and television are considered as standard household goods. Their availability is taken for granted and is thought to be independent of any decision to enrol on an educational course. Video-recording systems may mark one borderline, although even in this case 79% of all British households have video facilities. The figure rises to 92% for the age group between 16 and 59 (Sargant et al. 1997).

The main threshold comes with computer-based teaching and learning. Only 25% of all households and 32% of the 16 to 59 age group had PCs in 1998. Even in the United States, with one of the highest PC penetration rates in the world, only about 40% of households used PCs. Moreover, far from dramatically rising, increase is slow and may be reaching a plateau. Given that a sufficiently powerful PC, which includes modem and CD-ROM drive and the relevant standard software, costs between £700 and £1 500, such media requirements, which are a potential addition to the usual course costs, present a strong barrier for many potential students.

From a system point of view reception costs are variable costs. Consequently, their effect on average costs cannot be compensated by scale economies. If these costs are not transferred to the learner then they transform the average costs dramatically. We saw that the fixed costs of software development and adaptation for computer-based courses are already high. Generally only high enrolment courses are likely to justify computer-based learning where the development costs can be spread over large numbers of students. If reception costs were taken up by the institution, variable costs could soar by a factor of four or five for courses that require computer access. Such costs could not be accommodated in many normal budgets.

Computer-based learning may erect other barriers as well as the financial one, because of problems of competence and motivation. Those without computer skills may be reluctant to enrol, with consequent effects on the size and characteristics of the student body. It is reported for instance that the increased use of computer technology in the British Open University technology foundation course has reduced considerably the enrolment level of women (ibid.).

Table 5.1 gives a synoptic view of media with reference to their capabilities, their costs, and their implications for access.

The institutional level

The main difference between the course manager and the institutional manager with respect to media choice is that the course manager largely has to operate within the framework of those media already available. At the institutional level it may be possible to take strategic management decisions enabling the adoption of new educational technologies. Questions then arise about quality, effectiveness, access and equity.

Issues of quality and effectiveness

The institutional manager has to make sure that the teaching is effective and of an appropriate quality. The standards to be reached are never absolute but are defined by reference to similar institutions.

In considering media capabilities we have distinguished between presentation and interactivity, whether internal or external (table 2.2). Most of the more traditional technologies are unidirectional and are good for presentational purposes. Interactivity in the classical distance-education model is achieved either through correspondence (with the great disadvantage of delay) or through the introduction of face-to-face elements. The great divide, for the time being, is defined by the extent to which computer-based learning is introduced. External interactivity can be supported by email or computer-based communication, internal interactivity by CD-ROM or the Internet. However, technology may change again; interactivity may become available more easily as part of a merger of television and computing. Then Institutional managers would need to look into the options of interactive television, which allows some feedback. The required set-top boxes would be cheaper than a computer and less complicated to use.

Further, the institutional manager may also need to consider developments in the professional fields for which the institution is preparing its students. Many professions are making increasing use of computing and communication technologies so that students have access to the necessary technologies and need to learn about their application. It would not make sense to teach people about computer applications within their profession purely by print. An induction into the relevant professional practices becomes essential. For example, accountancy and architecture increasingly use CAD (computer-aided design) software to conduct their day to day business. In more academic fields like mathematics it is virtually impossible to teach statistics without reference to the relevant software packages (like SPSS) or ignore MathCAD software for modelling. As potential students become more and more computer literate their expectations change; they will come to expect more than the traditional chalk and talk, thus pressing for change both in conventional education and in open and distance learning. There may be arguments that flow from the nature of the subject matter being taught in favour of choosing a particular medium or combination of media.

Issues of costs and efficiency

We have seen that increased use of computer-based technology tends to drive up costs in two ways. It raises the fixed costs of course development and, by facilitating communication between tutor and student, is likely to increase variable costs for tutoring. Gains in quality, or in the richness of the educational experience, have to be set against these costs for both resource and communication media. We need, therefore, to ask whether there are opportunities to seek economies while making increased use of the advanced technologies. Three opportunities present themselves.

The first is to increase the size of the audience, so that development costs can be spread over a larger number of students. Historically this has been achieved by enrolling an increased number of students at the institution that has developed a course. But new patterns of inter-institutional co-operation may also make it possible to achieve economies of scale in course development. The Open Learning Foundation in Britain and FIT-Est in France serve as examples. In each case, a group of universities pool their resources to develop teaching material that any members of the group can use. At a European level initiatives like TERENA are beginning to demonstrate the potential of collaboration of this kind.

Table 5.1: Technologies for open and distance learning

Medium	Media characteristics	Educational strength or weakness	Cost implications	Implications for access
Face-to-face study	Simultaneous, two way, communication is possible	Adaptable; may allow immediate individual response to learner; can be highly motivating	Costs generally rise in relation to student numbers	Requires attendance at fixed time and place
Print	One-way communication Two-way communication possible where correspondence assignments are designed and returned through mail, fax or email	Provides convenient permanent record Limited in its effectiveness to motivate students May be of restricted value for some practical subjects	Significant fixed costs in developing printed materials. Reproduction costs used who economies for large print runs but with digital, just-in-time, printing may no longer do so	Generally no problems of access
Broad-casting (radio and television)	One way communication	Can motivate, excite, dramatise, illustrate Ephemeral unless students record off-air	Production costs generally higher than for print Television generally up to ten times as expensive as radio Transmission costs generally met by broadcasting authority	No problem of access, with universal access to radio and tv, but timing of broadcasts may be inconvenient

Medium	Media characteristics	Educational strength or weakness	Cost implications	Implications for access
Cassettes	Generally one-way communication. Audiocassettes occasionally used for delayed response to tutors	Similar educational qualities to broadcasts but not ephemeral	Production costs in principle as for broadcasting; costs in practice lower as lower quality is often acceptable Distribution cost falls on teaching institution	Problems of access only if students do not have audio or videocassette player (79% of households had video 1995)
Video-conferen-cing	Can be two-way synchronous communication, generally between two sites, or with many sites if one-way video and two-way audio	Allows up-to-date, live, two-way communication, giving a sense of immediacy. Ephemeral	Significant investment needed in videoconferencing equipment and ISDN line charges. Cost a function of number of sites involved	Access open only to those who can reach location with equipment
Computer-related learning	Allows two-way asynchronous communication	Allows simulations and activities that depend on computer capacity Can be used as communication medium	Heavy initial cost to develop computer-based learning material Significant personal investment needed for computer Cost of communication through Internet relatively low	Major, but reducing, problems of access. 25% of households had PC (1995) but smaller proportion had Internet access

Source: Based on Perraton and Hülsmann 1998

Second, where courses use computer-mediated communication, it becomes possible to build up searchable banks of frequently asked questions. If the existence of such banks in practice resolves learner difficulties, then they may increase the efficiency of tutors in responding to students. This is, of course, a long way short of arguing that a bank of questions and answers should replace individual or group tuition.

Third, in the development of computer-based learning, it may be possible to make major reductions in staff costs by using generic software. In some cases this will be ordinary, multipurpose, software available commercially. Good teaching can be built around standard wordprocessing and spreadsheet packages. But, beyond this, it may be possible to develop less standard software so that components can be re-used. If software development is concentrated on generic re-usable software, compatible with various shells or user interfaces, the time required to develop computer-based courses, might be reduced with consequent reductions of development costs. (Example: if you have developed generic software for an arts course, which handles the life and work of Matisse and includes software to recompose pictorial elements, you can do the same for the course in cubism. The software for remedial vocabulary training is likely to be quite similar across many languages.)

Institutional managers are likely to be concerned with equity and access as well as with costs and effectiveness. There are likely to be trade-offs here between maximising educational quality and widening access. If, for example, there are educational arguments for having a technology-rich course and social ones for keeping the cost down, the manager will need to make a social, educational and economic judgement about the educational mixture to be sought. For the manager, the initial planning decisions are likely to be about the investment cost of a particular course and the extent to which this can be recovered, over the life of the course, either from general funds or from student enrolments. But questions about variable costs can also have a significant bearing on the financial viability of a course and on access, at least where students pay fees to meet part or all of their costs. If student fees are set below the variable cost of a course, then the institution itself incurs additional expenditure with each extra student, so that its recurrent costs rise with increasing numbers. It has, therefore, a disincentive to recruit the extra number of students that may be called for to justify the original investment cost. If, however, all the variable costs are passed on to students, the institution is encouraged to increase recruitment, but may need to increase the price to students to a level that reduces access for significant numbers of them.

Recommendations for cost-effective media choice

We can summarise the conclusions of our work in twelve recommendations.

If no specific arguments are presented, go for textual media. If there is a choice to be made between print and screen, go for print. Print allows more flexible use.

In considering the broad choice between resource media and communication media, bear in mind that resource media are likely to have economic advantages. They allow for economies of scale as well as permitting internal interactivity.

Select carefully the features of internal interactive design. Some features provide valuable student learning opportunities over considerable periods at reasonable costs, whereas in-house development, for example, of complex simulations, can prove extremely costly.

Select, and plan with care, your use of communication media which do not generally allow scale economies.

Communication media need to be monitored in terms of their unit costs. These costs are variable or semi-variable and are likely to contribute the larger part of the aggregate unit costs (often rather more than two-thirds of the aggregated unit costs).

As a general rule, asynchronous communication has cost advantages over synchronous and group communication over individual. The choice of asynchronous and group communication may be defended in terms of efficiency where computer-mediated communication is used to support students. In any case, the cost of tutorial time is likely to be an important variable. Clear guidelines will probably be needed in order to limit the input of tutorial time (and consequently costs) and to adjust learner expectations.

Face-to-face tutorials may have motivational as well as academic benefits. Reports on their emotional effects are ambivalent. Some students gain in confidence by being able to position themselves well in the group, others lose in confidence. (It is interesting to observe that some institutions keep learning centres even when they have abandoned all face-to-face contact of students with staff. It is reckoned that such centres provide a focus of identification with the institution.)

Tutor marked assignments (TMA) provide learner support and may be used for assessment. Their use for assessment may be particularly important for courses leading to formal qualifications.

If videoconferencing is considered, analyse the savings in terms of opportunity costs. There is little chance of videoconferencing being advantageous in cost terms if no considerable savings in travel time and costs can be envisaged.

If your institution is into software development, concentrate on generic software in modular form. Archive the re-usable components. This will reduce development time (time to market) and, in consequence, costs.

In computer-based learning it is worth looking into the option of banking answers to emerging standard questions in course-specific 'frequently asked questions' archives for customised re-use.

All decisions have to take into account not only costs but also the market. We have observed two strategies: expansion and specialisation. Big providers must keep high profiles to keep up enrolment. Other institutions may go for more specialised audiences. An intelligent use of existing facilities, and the development of low cost wrap-around material, may make it possible to produce high-quality courses at relatively modest cost for specialised audiences.

Part II

Introduction to Part II

The second part of the book comprises some of the case studies undertaken. Not all of them could be included, partly because the data set was less complete or did not easily lend itself to a presentation in the form adopted. However, this information was not lost but taken into account as far as possible. The objective of the case studies was mainly to identify benchmark costs per student learning hour per medium.

We present in part II a selection of eleven case studies, which cover a range of educational technologies and are taken from diverse institutional settings. The research for most case studies included a visit to the institution. It was tried to secure two interviews interspaced by a day or two to allow time to study whatever cost documentation was made available to us. In some cases we had to rely on interviews only.

We tried as far as possible to structure the case studies in a consistent manner. After a short description of the institution and the course under consideration in general, we deal with 'resource media: inputs and costs'. Here we include all the media used in the course. We try to separate fixed and variable cost elements and to identify the unit cost due to production and distribution. We then turn to 'student support: inputs and costs'. Support is generally provided through communication media, which means that the costs are to a large extent variable costs. The aim is to identify the average cost per student (i.e. unit costs) due to support. The unit costs of production and distribution together with the unit cost of student support allow us to identify the aggregate unit costs required for the cost analysis.

The last part of the case study generally is devoted to cost analysis. Here we bring the elements determined in the former sections together to identify the 'total direct costs' and the 'average costs per student'. Average costs are calculated on the basis of the number of students enrolled but if possible the average cost figure for the projected student enrolment at the end of the shelf life of the course is included. If, as it is often the case, courses have no specified lifetime but are changed on a rolling basis, we assume a five years lifetime and add the maintenance cost over five years to the development costs.

The last section of the cost analysis lists the different parameters of cost per student learning hours. These are:

Cost/SLH (course): This is defined as the fixed costs of course development divided by the overall number of student learning hours either identified by the provider or inferred from the CAT points of the course.

Cost/SLH (media): This is, unlike the first one, a bottom-up measure. The same fixed costs may be used but the student learning hours are based on the inputs provided. This is done on the basis of explicit conversion assumptions, e.g. 50 pages of print require 10 hours of student learning time.

Cost/SLH (print), cost/SLH (video) or cost/SLH for other media: These measures are defined as the fixed costs of development of the respective medium divided by the student learning time attributed to it. Similar explicit assumptions are used in order to relate media inputs to learning time.

The results are drawn together in the table summarising the case studies. We included in this table an explicit account of the average cost function since it conveys much more information the average cost figure on ist own. Most importantly it allows to identify the aggregate unit costs (i.e. the constant term of the average cost function). The aggregate unit costs define the line below which the average costs cannot fall. Therefore the comparison of the figure obtained for the given level of enrolment and the aggregate average costs give a measure of the yet-unrealised potential of scale economics. It also makes it possible to compare aggregate unit costs across the case studies. However, these figures have to be read against the level of the course, reflected either in the CAT value or the SLH of the course.

All the figures presented have to be considered as indicative rather than representative, in the sense that they are 'real world' figures drawn from individual case studies rather than a systematic sampling of Europe-wide experience. It would be useful to conduct a large-scale survey based on the adopted methodology.

The British Open University: two case studies

The British Open University was founded in 1969. It caters for students in the United Kingdom (134 000), other European Communion countries (8 000), and has a considerable enrolment from outside Europe (14 600; all figures 1996/7). The bulk of the student population is doing undergraduate work where courses are well-balanced between Science, Engineering and Mathematics (each faculty enrolling about 20 000 to 25 000 students) and Social Sciences, Business Management and finally Humanities.

The age profile is normally distributed around the end thirties. The total expenditure for 1996/7 has been indicated as £215.3 million.

Sometimes referred to as the Rolls Royce of distance education, the high quality teaching material has helped to free distance education from the image of second chance but second best education. Being well known for leading edge technology teaching the traditional print based material is also highly regarded and used in the universities as well as being bought by a wider public.

We were given the opportunity to look into the costs of two courses, one in the faculty of Health and Social Welfare one in the faculty of Mathematics. The first course was a 30 CAT point course and supported by print and video media, the second was a 60 CAT course and supported by print, CD-ROM, television and videocassettes.

The OU stands out of providing courses with a high level of cost per student learning hour. Though this is not by itself an index of quality, it is consistent with the image of the UKOU as a high-quality provider. At the same time the OU manages, because of its high enrolment level, to keep average cost per student at least in line with average costs observed elsewhere.

Case study 1

A second level undergraduate course offered by the School of Health and Social Welfare of the Open University/United Kingdom

The course examined here is a second level undergraduate course offered by the School of Health and Social Welfare. It requires at least 220 hours of study and carries 30 CAT points (Credit Accumulation and Transfer points). The course can be used as a module in different degree and diploma programmes. The course fees in 1996 were £250.

The course covers relevant concepts such as community and neighbourhood. It addresses such issues as the conflict of control and care, discusses local and government policies on community care and refers to the relevant legislation.

The media used are: text, video, audio. The respective material can also be bought as an independent package for group work in community settings.

In the following we consider as direct course costs development, maintenance, production, distribution and cost of student support. Administration costs are ignored since they are not specific to the course.

Resource media: inputs and costs

The media used in this particular course were text, audio and video. Development costs of these media involve authoring tasks and design tasks. Development costs include all activities which result in the resource material ready for replication.

Development costs

The printed material developed for the course consists of 13 units (generally a unit consists of 48 pp), five of them being labelled as supplementary material (because they are updated more frequently than the units), seven audio cassettes of 30 minutes each and one video tape of 25 minutes.

Sometimes courses have to be updated. These costs are part of the maintenance costs and incurred only after some years when the course needs to be partially updated. The maintenance costs average £5 000 from 1993 to 2000, i.e. altogether amounting to £40 000.

Table CS 1.1: Fixed costs of development Currency: Sterling

		1990	1991	1992	Totals
Salaries	Academics (4 staff over 2.8 years)	112 000	144 000	150 000	
	Other staff	30 000	31 125	32 250	
	Total salaries	142 000	175 125	182 250	499 375
Development	Fixed Print		8 125	7 150	15 275
	Audio production[a]		11 200	8 400	19 600
	Video production[a]			27 000	27 000
	Other[b]	3 600	20 213	34 242	57 305
Total Development	(excluding salaries)	3 600	39 538	76 792	119 930
	(including salaries)				619 305

Source: based on OU budget details of the course. NB Budget costs reflect internal recharge rates which may differ from actual costs. Costs are in 1996 prices. Notes: a: production costs in this case are in fact development costs rather than replication costs; b: the heading other includes all other headings than print, audio and video.

Production cost

Production costs are variable costs: they are sensitive to student numbers. In OU terminology they are referred to as 'stock purchases'. The unit costs of printing a unit (= 48 pp) is indicated as £0.96. The projected number of students was 8 000 over eight years. There were two consecutive print runs of 5 000 for four units in 1991 and another four in 1992. The cost is 2 x £19 200 = £38 400. However, the expected number of students up to the year 2000 is near to 8 000. Hence the print costs will eventually come up to slightly more than £60 000.

The supplementary material was not all printed in advance. In particular the TMA booklet is updated each year and therefore a variable recurrent cost factor. The production cost for the supplementary material up to 1996 amounted to £36 650. Additional costs of 4 x £2 010 = £8 040 are expected for the years 1997 to 2000 when the course will terminate. Hence the total production cost of supplementary material will amount to about £45 000. The total production cost of printed material then amounts to £105 000.

Audio and video replication is not done all in advance, but rather on a recurrent basis. Table CS 1.2 summarises the costs up to 1996.

Table CS 1.2: Audio and video production costs Currency: Sterling

			1992	1993	1994	1995	1996	Total to 96
Audio	2xC60	number[a]	3 000	3 000	3 000	3 000	3 000	
		unit cost	0.3	0.3	0.3	0.3	0.3	
		Subtotal	900	900	900	900	900	
	1xC90	no	1 500	1 500	1 500	1 500	1 500	
		unit cost	0.39	0.39	0.39	0.39	0.39	
		Subtotal	585	585	585	585	585	
	Total	Audio	1 485	1 485	1 485	1 485	1 485	7 425
Video	1xE90	no	1 500	1 500	1 500	1 500	1 500	
		unit cost	2.15	2.15	2.15	2.15	2.15	
	Total	video	3 225	3 225	3 225	3 225	3 225	16 125
Total	Audio+	Video	4 710	4 710	4 710	4 710	4 710	23 550

Source: based on OU budget details of this course. NB Budget costs reflect internal recharges which may differ from actual costs. Costs are in 1996 prices. Notes: a: the number here is 3 000 because we have 2 x 1 500 copies of 60 min cassettes.

The projected number of students up to 2000 is about 8 000. In addition to student use, copies of course materials are also produced for course team members and other colleagues, for tutors, for pack and other sales, and for the OU library and regional centres. However, if we base our calculation on a target figure of 8 000 students we have to add 500 copies of each category since, as the numbers in CS 1.2 indicate, only 7 500 copies were produced so far. Therefore additional costs of £ 300 (for the 2xC60), £195 (for 1xC90) and £1 075 (for 1xE90) will be incurred. This means we will end up with a total of £7 920 for audio, and a total of £17 200 for video. Hence the production cost for non-print media amounts to slightly more than £25 000 till the end of the course.

Adding up the production cost of print (i.e. £105 000, for the units plus the supplementary material) to the total production cost of video and audio given above, the production costs will amount to £13 000. Given the target of 8 000 students we have a unit production cost of about £16.

Distribution cost

Postage packing and handling costs were as listed in the table CS 1.3.

Table CS 1.3: Distribution costs Currency: Sterling

	1993	1994	1995	1996	Total to 96
Student no	1 244	1 325	1 158	963	
Postage, packing + handling	6 531	6 956	6 080	5 056	24 623
Unit cost	5	5	5	5	

Source: OU budget details of this course. NB Budget costs reflect internal recharges which may differ from actual costs.

The distribution cost will eventually amount to £5 x 8 000 = £40 000.

Cost of student support

Student support consists of two elements (i) correspondence tuition, which consists of detailed feedback to students to their assignments (i.e. tutor-marked assignments or TMAs) and (ii) face-to-face tutorials. For a 30 CAT point course, like the one under consideration, four assignments and eight contact hours are normally planned. A tutorial group consists of 20 students.

Tutor-marked assignments

The assignments are marked with great care and are commented on in detail. To mark an assignment cost £12 plus an additional element of expenses (£0.75). Given the number of assignments (four), we have 4 x (£ 12 + £ 0.75) = £51, the corresponding per student cost.

Tuition

The hourly rate for tuition is about £25 which amounts to £200 for eight contact hours. Additional student-related fees of £7.70 are to be taken into account leading to an additional £154. Hence the tutorial element cost per student is £200/20= £10. To get the unit cost due to tuition we have to add the £7.70 to that and get £17.70, or £18. Hence the total unit cost of student support (TMA and tuition) is about £69.

These are planning figures. The actual figures in the cost summary presented in table CS 1.4 vary slightly for TMAs, since not all students complete all the assignments (payments are made to tutors for completed assignments).

Table CS 1.4 corresponds largely with the benchmark figure, which indicates the total student support cost as about £69. We take the aggregate unit costs to be about £90 (i.e. £69 for support, £16 production and £5 distribution).

Table CS 1.4: Student support Currency: Sterling

	1993	1994	1995	1996	Total
Student numbers	1 244	1 325	1 158	963	
TMA	63 879	70 080	56 776	48 632	239 367
Unit cost TMA	51	53	49	50	
Tuition	24 880	26 831	24 318	20 223	96 252
Unit cost tuition	20	20	21	21	

Source: based on OU budget details of course.

Cost analysis

The cost analysis includes the calculation of the total and average cost function for the projected student number and the cost per student learning hour.

Cost functions

The assembled data allow us to determine the total cost function:

$$TC = F + V \text{ x } s$$

$$TC = £\,660\,000 + (£90 \text{ x } 8{,}000) \Rightarrow$$

$$TC = £\,660\,000 + £\,720\,000 \Rightarrow$$

$$TC = £\,1\,380\,000$$

as well as the average cost function:

$$AC = \frac{F}{s} + V$$

$$AC = \frac{£\,660\,000}{8\,000} + £\,90 \Rightarrow$$

$$AC = £\,83 + £\,90 \Rightarrow$$

$$AC = £\,173$$

The average cost reflects the economies of scale: high fixed costs of development can be distributed over the number of students. In this case the cost per student resulting from the development of teaching material does not exceed the variable cost per student.

Cost per student learning hour

The costs of development and maintenance amount to £ 660 000. The number of student learning hours the course generates is said to be at least 220. The cost of developing one student learning hour based on the stipulated number of learning hours for the course is:

$$\text{Cost/SLH(course)} = \frac{£\,660\,000}{220} = £\,3\,000$$

The OU does not specify the amount of study time to be devoted to each medium. For these purposes, however, we have assumed that the number of student learning hours the course provides for (in terms of material generated for it), amounts to at least 13 units of print or 130 SLH(print), 3.5 SLH(audio) and 1.5 SLH(video). According to our assumptions, therefore, the student learning hours for which material was developed amounts to 135. Consequently, we can calculate the cost per student learning hour provided for:

$$\text{cost/SLH(medium)} = \frac{£\,660\,000}{135} = £\,4\,889$$

It is not possible to determine the cost per student learning hour by medium since the main cost driver, staff time (especially academic staff time), is not attributed to specific media. However, we know the OU benchmark costs for academic time per medium and can calculate the cost using information about the general salary scale in higher education. Based on this we get the following cost per student learning hours:

cost/SLH(print) between £300 and £1 500

cost/SLH(audio) between £1 000 to £16 000

cost/SLH(video) between £10 000 and £80 000

The variations are partly due to the quality specification of the product (this is true for all three cases), partly (in the print case) on the choice between commissioning an external writer and developing a unit in-house.

Table CS 1.5: Cost summary of an undergraduate course offered by the School of Health and Social Welfare/OU

Currency: Sterling

	Subtotals	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Student numbers		0	0	0	1 244	1 324	1 158	963	850	850	850	850
Accumulated student					1 244	2 568	3 726	4 689	5 539	6 389	7 239	8 089
Development cost												
Staff		142 000	175 125	182 250								
Other		3 600	39 538	76 792								
Subtotal		145 600	214 663	259 042								
Total development cost	619 305											
Maintenance cost					5 000	5 000	5 000	5 000	5 000	5 000	5 000	5 000
Total maintenance cost	40 000											
Development plus maintenance cost	659 305											
	Unit											
Production	16											
Distribution	5											
Support												
Tuition	18											
TMA	51											
Total support costs	69											
Total unit costs	90				111 960	119 16	104 220	86 670	76 500	76 500	76 500	76 500
Accumulated unit costs					111 960	231 12	335 340	422 010	498 510	575 010	651 510	728 010
Total cost function				619 305	736 265	855 42	959 645	1 046 315	1 122 815	1 199 315	1 275 815	1 352 315
Average cost function					592	335	260	226	206	192	180	172

NB Budget costs reflect internal charges which may differ from actual costs.

Case study 2

A course in mathematical modelling offered by the Faculty of Computing and Mathematics of the Open University/ United Kingdom

This course aims at learners who use mathematical reasoning but are interested in extending it to a wider realm of applications. It is also expected to be interesting for teachers teaching A-level applied mathematics.

The course concentrates on the development of mathematical models for real-world applications. The applications are largely taken from physics covering statics, Newton's laws, and oscillations as well as the motion of rigid bodies. The mathematical techniques required for this extend from numerical methods, differential equations, and linear algebra to advanced calculus.

The course is a level two course and carries 60 CAT points. Students are advised that the course is likely to require a minimum of 448 student learning hours: i.e. at least 14 hours per week for 32 weeks). It counts towards a BA/BSc/MMath.

Resource media: inputs and costs

The course consists of seven blocks. Each of them contains four units of printed texts and one-CD-ROM. Further audio-visual media (TV and videocassettes) are added to enhance the learning. A summary of the fixed costs is given in table CS 2.1.

Fixed costs of development

The main teaching resource remains the printed text. With 28 units of about 50 pages each a student has to work through a formidable 1 400 pages of mathematics teaching.

Table CS 2.1: Fixed costs of development

Fixed costs	Type	Amount	Unit cost	Total
Salaries	Academic staff; support & secretarial staff, editorial and design			1 777 392
Development	Consultants			51 030
	Other			48 402
	Subtotal			99 432
Production	Fixed print	(28 units & supplements)		33 558
	CD ROM	Up to 7		283 000
	TV	4 x 25 min	50 784	203 136
	Video	10 hours		380 000
	Subtotal			899 694
	Total fixed costs			2 776 518

Source: OUUK budget data of this course; all costs in £'98; NB Budget costs reflect internal charges, which may differ from actual costs.

Interactive CD-ROMs enhance the printed texts. The CD-ROMs were developed partly in co-operation with the BBC partly by the computing department of the OU. They are supported by Mathcad Pro7 software.

Variable costs of production

The input in resource media for this course is considerable. The participation rate is estimated to be about 1 000 students per year over 8 years. The number of students for whom materials have been prepared up to now were 1 795. This is the basis on which the variable costs incurred up to now have been calculated.

Hence the variable cost for 1 795 students amount to £171 064. We may also estimate the total variable cost for the whole lifetime of the course on the basis of 8 000 students. This would amount to 8 000 x £ 36.43 = £291 440.

However, the variable costs of production are not the only variable costs. We have to consider the variable costs of student support and the costs of distribution. (We had to neglect distribution costs; as the course was just being launched at the time of our case study, cost data were not available.)

Table CS 2.2: Variable costs of production

Print	Variable costs per student	No of students		Costs
Units	10.70	1 795	2 runs	38 413
Supplementary texts	4.65	1 795	1 run	8 347
Subtotal	15.35			46 760
Video cassettes				
E90	2.13	1 795	2 copies	7 647
E120	2.60	1 795	2 copies	9 334
E180	3.43	1 795	1 copy	6 157
Subtotal	8.16			23 138
CD-ROM				
CD-ROMs	1.17	1 795	8 discs	16 801
Software licences	11.75	1 795	4	84 365
Subtotal	12.92			101 166
Total	36.43			171 064

Source: OUUK budget data of this course; 1998. NB Budget costs reflect internal charges which may differ from actual costs.

Student support: inputs and costs

Student support consists of three elements: (i) eight tutor-marked assignments and (ii) fifteen face-to-face tutorials and (iii) a summer school.

Tutor-marked assignments

The marking of assignments (TMA) is part of a process of teaching. It involves much more than pointing out errors. The assignments are marked with great care and are commented on in detail. To mark an assignment costs £12 in TMA fees payable to the tutor plus an additional element for student related expenses the tutor may incur (£0.75). Given the number of assignments (eight), we have 8 x (£ 12 + £ 0.75) = £ 102 as corresponding unit cost due to TMAs.

Tuition

The hourly rate for tuition is £25.49, and fifteen contact hours are provided for. Since about twenty students form a group, the unit cost per student due to the total of fifteen hours tuition is £382/20 = £19. Together with a student-related fee of £15 we have a unit cost due to tuition of £34. The unit costs of TMA and tuition amount to £136. The results are summarised in table CS 2.3.

Table CS 2.3: Student support: inputs and costs

Number of inputs	Type of inputs	Costs of inputs
	Tuition	
15 x	Contact hours @ £25.49 per hour	382
20 x	Student related fees @ £15.40 per student	308
	Subtotal tuition	690
	Unit tuition @ 20 students	35
	TMA	
20 x	TMA fee	1 920
20 x	TMA expenses	120
	Subtotal TMA	2 040
	Unit TMA	103
	Total unit costs of student support	138
	Total unit cost (inc. unit production cost)	174

Source: OUUK budget data of this course. NB Budget costs reflect internal charges, which may differ from actual costs.

Table CS 2.3 makes it possible to calculate the variable costs for student for 1 795 students and equally predict the total variable costs for 8 000 students due to student support. The figures are

1 795 x £138 = £247 710 and 8 000 x £138 = £1 104 000.

The total variable cost due to production and student support for 1 795 students are £418 774 (see table CS 2.2), for 8 000 students £1 395 440.

The following cost analysis includes an estimation of the projected total direct costs of the course, the average cost (including the average cost function) and the various costs per student learning hours.

Total direct costs

A synoptic view of the direct course costs, fixed and variable is given in table CS 2.4.

Table CS 2.4: Total direct costs

Type of costs	Number of students 1 795	Number of students 8 000
Fixed costs	2 776 518	2 776 518
Variable costs	415 184	1 392 000
Total	3 088 848	4 268 518

Source: OUUK data of this course.

Average cost per student

Since the fixed costs as well as the total variable costs per students are known, we can calculate:

For $s = 1\,795$

$$AC = \frac{£\,2\,776\,518}{1\,795} + £\,172 = £\,1\,547 + £\,172 = £\,1\,719$$

and for $s = 8\,000$

$$AC = \frac{£\,2\,776\,518}{8\,000} + £\,172 = £\,347 + £\,172 = £\,519$$

Costs per student learning hour

Since the course is likely to take at least 448 student learning hours to complete, the cost per student learning hour for the whole course is at most:

$$\text{Cost/SLH(course)} = \frac{£2\,776\,518}{448} = £6\,198$$

The OU does not specify the amount of study time to be devoted to each medium. However, using our conversion norms for media input into student learning hours, we get 28 units at 10SLH = 280 SLH; 10 hours video = 10 SLH; 2.4 hours TV= 2.4 SLH. The SLH generated by the CD-ROMs have been estimated to be in the range of half an hour to two hours per week, i.e. between 14 and 56 hours. Altogether this amounts to between 306 and 348 SLH.

$$\text{cost/SLH(media)} = \frac{£\,2\,776\,518}{306} = £\,9\,074$$

or

$$\text{cost/SLH (media)} = \frac{£\,2\,776\,518}{348} = £\,7\,979$$

The cost per medium cannot easily be disaggregated since the development of each medium did draw academic staff time to an extent, which cannot be identified. Therefore the following estimates must be considered as minimal.

Since the CD-ROMs are interactive, the respective student learning hours are difficult to determine. Course designers assume that a student spends over a period of 28 weeks between half an hour and two hours using the CD-ROMs

This would mean that the total input of seven CD-ROMs provide for a learning time of 1/2 x 28 SLH= 14 SLH or 2 x 28 SLH = 56 SLH. Consequently we have:

For SLH = 14 we get

$$\text{cost/SLH(CD - ROM)} = \frac{£283\,000}{14} = £\,20\,414$$

for SLH = 56 we get

$$\text{cost/SLH(CD - ROM)} = \frac{£\,283\,000}{56} = £\;\;5\,054$$

The cost per student learning hour per hour television can be inferred from table CS2.1. Since the fixed costs of development for 4 x 25 min TV were given as £ 203 136, and 2.4 x 25 min =60 min or an hour, we have, assuming SLH is equivalent to viewing time:

$$\text{cost/SLH(TV)} = £\,50\,784 \text{ x } 2.4 = £\,121\,882$$

The cost per student learning hours per video also can be inferred from table 2.1. Always assuming SLH is equivalent to viewing time, we have:

$$\text{cost/SLH (Video)} = \frac{£\,380\,000}{10} = £\,38\,000$$

NKS Distance Education in Norway: two case studies

'NKS Distance Education' (in Norwegian: NKS Fjernundervisning) is part of the NKS group. Its history goes back to 1914 when E.G. Mortensen founded a correspondence school in Oslo, which became widely known as NKS. In 1986 the NKS College started as a private but publicly accredited provider in for post-secondary education. It has its own publishing house, opened in 1992 a branch in Budapest (Hungary) and a Business Institute and a Business school founded in 1993 and 1996 respectively.

As a private institution NKS must be quite alert to its markets. This is reflected in the organisational structure where separate departments are cultivating the relationships to different market segments (e.g. the corporate market, the market of public-sector institutions, learners who want to learn in mixed mode or alone). Consequently NKS is able to provide for long-term classical curricula as well as responding to short-term demands reflected in the labour market.

We were able to look at two courses. One, the Norsk course provides post secondary education for adults, the other provides teacher training for primary school teachers. Both courses were largely print-based but included videocassettes.

Case study 3

The Norsk Course: the upper secondary curriculum taught at a distance by NKS Distance Education in Oslo/Norway

The course covers the upper secondary school curriculum. The target group consists of adults who want to complete their secondary education in order to qualify for higher education. The course therefore comprises years 1 to 3 of the upper secondary school. Since the course is treated as equivalent to three years of conventional upper-level secondary education, the student learning hours (SLH) are estimated on this basis. The course extends over 5+5+4 = 14 hours per week in each of the three years of its duration. The school year has about 40 weeks. Hence the number of SLH is 40 x 14 = 560 per year. The following calculations refer to one year.

The number of students recruited so far is 418. The number expected for the lifetime of the course is 1 500. We calculate the average cost per student for both cases.

Resource media: inputs and costs

There are resource inputs of print and video. The inputs were standardised in unit equivalents (UE). A UE (print) = 50 pages and a UE (video) = E60, i.e. a one-hour cassette. For both types of resource material we classify the costs in terms of fixed costs of development and variable costs of production. The variable costs in both cases were calculated on the basis of the projected total enrolment.

The resource material consists of printed material and videocassettes. The printed material specifically developed for the course consists of three booklets. In addition to the print material developed by NKS a set of textbooks is provided called 'Bruer' (bridges). The textbooks are to be purchased by the students. The video input consists of 12 video sequences of 10 to 15 minutes.

Print

The printed material developed for the course consists of 10 sections of a total of about 420 pages which is equal to 8.5 unit equivalents of print. Following the cost classification of NKS for the cost of development we distinguish author-related costs ('Redaksion') which include costs for authoring, consultancy, linguistic and pedagogic advice and design-related costs ('Grafisc') which include setting, layout, cover design and pre-print. The bulk of the author-related costs, about 65%, consists of fees for authors.

Table CS 3.1: Resource inputs and their costs: print

Inputs and type of costs		Cost £'95
No of UE	8.50	
No of copies	1 500	
Development costs		
Author related		11 910
Design related		2 113
Subtotal: fixed costs of development		14 023
Production costs		11 634
Total		25 657

Source: NKS data

From table CS 3.1 we can conclude that the cost for development of a UE (print) is as follows:

$$\text{cost/UE(print)} = \frac{£\,14\,023}{8.50} = £\,1\,650$$

The variable cost per student due to replication of the material (unit cost of production) comes to

$$\text{Unit cost of production} = \frac{£\,11\,634}{1500} = £\,7.80$$

In addition to the print material developed in-house, additional sets of textbooks were bought in and given to students. The unit cost of a set amounts to £ 85.

Video

The video input provided consisted of 12 video sequences of 10 to 15 minutes, which amounts to 3 UE (video), or 3xE60. The fixed costs of development came to £62 506. The fixed cost of development for a UE (video) therefore is £62 506/3 = £20 835. The variable cost of production per student (unit cost) is £8 415/1 500 = £5.60.

Table CS 3.2: Resource inputs and their costs: video

Inputs and type of costs		Cost £'95
No of E60	5.60	
No of copies	1 500	
Development costs (fixed)		62 506
Production costs (variable)		8 415
Total		70 921

Source: NKS data; cost £'95

Student support and costs: inputs and costs

There were no face-to-face tutorials. The support consisted of tutor-marked assignments (TMAs) and provision made for telephone tutorials.

Tutor marked assignments

Since students take external exams, the submission of TMAs is voluntary. Students are given the opportunity to submit up to 10 assignments, which would be commented on and marked by a tutor. The cost per assignment is calculated according to the following formula:

Table CS 3.3: The cost structure of TMAs

tutor marking fee	x social cost factor	+ handling cost	= assignment cost
£5.65	x 1.3	+ £0.81	= £8.16

Source: NKS data; cost £'95

Student participation is voluntary and, in fact, quite low. It is described in table CS 3.4. It is based on the student participation so far (based on the sample of the 418 students enrolled so far). Out of the maximum of 418 x 10 assignments only 901, i.e. 22% were submitted so far. Based on this participation rate we expect the total cost due to TMAs to be 22% x 1 500 x 10 x £8.16 = £26 928.

Table CS 3.4: Cost of tutor-marked assignments (TMA)

No. of TMA offered	1	2	3	4	5	6	7	8	9	10	0
No. of students who have done the respective no of TMA	84	31	19	13	4	16	7	11	7	33	193
No. TMA completed	84	62	57	52	20	96	49	88	63	330	0
Cost per TMA (subtotals)	685	506	465	424	163	783	400	718	514	2693	0
Total TMA cost	7 352										

Source: NKS data; cost £'95; Note: total no of students here 418, i.e. the students so far recruited

Telephone

In addition to interaction through marked assignments, students may telephone their tutors for clarification. It seems, however, that most of the content-related telephone advice is handled by NKS staff, either in the customer services department or in education. Though tutors theoretically can claim cost for giving content-related advice, no claims have been made so far which indicates that students turn for advice rather to NKS staff rather than to tutors. Unfortunately, the extent to which student make use of the telephone to seek content clarification is not documented. However, NKS management judges it to be quite modest.

Administration

The enrolment costs per student were given as £1.70 and the administrative mailing as £4. The table calculates the total costs incurred in the direct administration of the course both based on the number of students participating so far and on the predicted number.

Table CS 3.5: Actual and projected administrative costs

	No of students	Enrolment cost	Mailing costs	Total costs
based on sample	418	711	1 672	2 383
based on projection	1 500	2 550	6 000	8 550

Source: NKS data; cost £'95

Cost analysis

The cost analysis consists of a summary of the direct course costs, a determination of the average cost per student (and the respective cost function) and finally the cost per student learning hour.

We are now able to draw together all the direct course costs so far. The costs are re-classified as fixed and variable costs in order to allow us to derive the average cost function in the next section.

Total direct costs

The information can also be displayed in terms of the total cost function, which sums up the fixed and variable cost. (F represents the total fixed costs and V x s the total variable cost. V in itself stands for the variable cost per student or the unit cost; when multiplied by the number of students we arrive at the total variable cost.)

Table CS 3.6: Student support and costs: inputs and costs: summary of direct costs

Total direct cost	Based on sample	Based on projection
Fixed costs		
Development cost print	14 023	14 023
Development cost video	62 506	62 506
Subtotal fixed costs	76 529	76 529
Variable cost		
Production cost print	3 242[a]	11 634
Production cost video	2 341	8 400
Bought in books	35 530	127 500
Assignments	7 352	2 6928
Mailing	1 672	6 000
Enrolment	711	2 550
Subtotal variable costs	50 848	183 012
Total costs	127 377	259 541

Source: NKS data; cost £'95. Notes: a: since the material was printed for the projected number of 1500 students we divided the production cost by the corresponding proportion of the sample enrolled.

Given this notation we have:

For $s = 418$

$TC = £\,76\,529 + £\,50\,848 = £\,127\,377$

For $s = 1\,500$

$TC = £\,76\,529 + £\,183\,012 = £\,259\,541$

Average cost per student

The total cost equation above allows us to determine the average cost per student.

$$V = \frac{£\,50\,848}{418} = \frac{£\,183\,023}{1500} = £\,122$$

TC = F + V x s can be transformed into AC = F/s + V where V stands for the unit costs. We calculate AC for s = 1500 since this will be the average cost per student at the time the course terminates. The average cost function therefore is

$$AC = \frac{£\,76\,529}{s} + £\,122$$

For s = 418

$$AC = \frac{£76\,529}{418} + £122 = £183 + £122 = £305$$

For s = 1 500

$$AC = \frac{£76\,529}{1500} + £122 = £51 + £122 = £173$$

Average cost per successful student

Students of NKS take public exams. Therefore from the point of view of NKS, completion rate could be defined as the percentage of students who have completed all their assignments successfully. Using this standard, the completion rate is low at between 10% and 20%. A better standard would be the number of students who passed their exams. But this information is not accessible by NKS because of the data protection laws, which excludes NKS from such access. However, it is known from surveys that about 55% students are confident enough to sit for the exams. Informal discussion with NKS staff suggested a pass rate of 50%, which would mean that of an original cohort of 1500 students (50/100 x 55/100 x 1500) or 412 students will get the qualification. If we then attribute the fixed costs to the successful students (and effectively write off the variable costs for unsuccessful students) we get an average cost per student of AC = £76,529/412 + £122 = £186 + £102 = £308.

Cost per student learning hour

The overall number of student learning hours generated by the course was 560. Therefore we get:

$$\text{cost/SLH(course)} = \frac{£76\,529}{560} = £137$$

To calculate the cost of development for all the resource material against the student learning hours, for which the material provides, we have:

$$\text{cost/SLH(media)} = \frac{£76\,529}{88} = £870$$

We have, however, to draw attention to the role of the bought-in material (the set of textbooks mentioned in the introduction). Most of the learning time is not developed at the fixed costs indicated since much is bought in. A more reliable measure is the cost per learning time by medium based on the actual amount of text and the time of video developed.

We use the following conversion conventions: A UE(print) it taken to provide study material for 10 hours, hence 1 UE(print) = 10 SLH. In case of video we identify the learning time with the exposition time, hence: 1 UE(video) = 1 SLH. We then can compare the cost per student learning hour:

$$\text{cost/SLH(print)} = \frac{£\,14\,023}{8.5 \text{ x } 10} = £\,165$$

$$\text{cost/SLH(video)} = \frac{£\,62\,502}{3} = £\,20\,835$$

This suggests that it costs about 120 times as much to generate a student learning hour video than it costs to generate a student learning hour print. Obviously such costs are only indicative. It costs more to make a carefully presented video, which necessitates the deployment of a film crew than filming a lecture.

Case study 4

Barnehagen: a course for teachers and social workers at NKS Distance Education in Oslo/Norway

The course is intended for teachers and social workers, working with age groups ranging between 4 to 10 years old children. The course content emphasises the transition to schooling: only recently the year of school entry in Norway has been lowered from seven to six. Hence the course is targeted at teachers and social workers facilitating this transitional period. The course consists of seven modules and a project assignment. The duration of the course is 1.5 years or three semesters. The student learning hours specified for this course were 700. Up to the time of data collection (August 1995) 638 students were enrolled. The course had been operating since August 1993.

Resource media: inputs and costs

The teaching materials provided for this course consisted of printed material and 7.5 hours of video.

Print

The teaching materials provided for this course consisted of seven printed texts and two supplementary texts. Translated into unit equivalents of 50 pages, the print input amounts to 9.5 UE (print). Table CS 4.1 summarises the fixed costs of development for the printed material. In the first semester the material 1 to 3 is studied, during the 2nd semester 4 to 7. The third semester is reserved for the assignment.

Table CS 4.1: Fixed cost of development of printed material

Text no	Booklets	General[a]	Total
No. of pages	524		
Author related			
Project management	3 074	1 292	4 366
Author	3 843	56 903	60 746
Consultancy	1 675		1 675
Ling./paed. advice	6 522		6 522
Correction/control	1 775	18	1 793
Other	97		97
Subtotal	16 983	58 213	75 199
Design related			
Graphics	192		192

Setting	624		624
Illustrations	609		608
Cover	673		674
Page make up	2 548		2 548
Correction	430		430
Divers	114	922	1 036
Subtotal	5 190	922	6 112
Total			81 311

Source: NKS data; 1996; Notes: a: this column includes costs which cannot be attributed to any single booklet.

The production costs of the printed material are summarised in table CS 4.2. These amount to £7 761. For the number of students enrolled the unit production costs for printed material therefore come near to £12 (i.e. £7 761/638).

Table CS 4.2: Variable costs of production

Production	All texts including supplementary texts
Paper	56
Cover print	610
Print	4 328
Binding	77
Reproduction	657
Other	2 033
Total	7 761

Source: NKS data; all costs in £'96

Video

The video input is considerable. Altogether 7.5 hours of video are provided for: two 20 minute videos, two 60 minute videos and three 90 minute videos. Development costs were indicated as £23 695. No detailed breakdown was given for production costs. Together they were said to be about £30 000.

The videos for this course were not produced from scratch but were edited versions of live satellite transmissions. This explains the large difference of development and production costs of videos as compared to case study 3, which refers to the same institution.

Student support: inputs and costs

Student support consists of tutor marked assignments (TMAs) and telephone advice if required. No face-to-face sessions are provided.

Tutor marked assignments

Students are given the opportunity to complete eight assignments. The cost per assignment is calculated according to the following formula described in table CS 4.3.

Table CS 4.3: the cost structure of TMAs

tutor marking fee	x social cost factor	+ handling cost	= assignment cost
£8.29	x 1.3	+ £0.81	= £11.59

Source: NKS data; all costs in £'95

The assignments are voluntary since examinations are external. According to table 4.4, the total number of assignments already completed amounts to 3449 out of a total of possible 5 104 (i.e. if all the students enrolled already would have completed all their assignments). This is a relatively high participation rate of 68%. This may be explained by the practical relevance of the course to the target audience.

Table CS 4.4:cost of tutor marked assignments (TMA)

No of TMA offered	1	2	3	4	5	6	7	8	0
No of students who have done the respective no of TMAs	42	20	20	13	17	6	50	348	127
No of TMA completed (subtotals)	42	40	60	52	85	36	350	2784	0
Cost per TMA (subtotals)	487	463	695	603	985	417	4055	32258	0
Total TMA cost									39964

Source: NKS data; all costs in £'95

Unit mailing costs were £8.13. For 638 students we have a cost of £5 187. Enrolment cost per student were £3.25. For 638 students the total enrolment costs were £2 074. Hence the total unit cost amounts to £7 261. The total unit costs incurred due to mailing and enrolment are £11.38.

Telephone

In addition to interaction through marked assignments, students may telephone their tutors for clarification. It seems, however, that most of the content related telephone advice is handled by NKS staff, either in the customer services department or in education. Though tutors theoretically can claim cost for giving content related advice, no claims have been made so far which indicates that students turn for advice rather to NKS staff rather than to tutors. Unfortunately, the extent to which student make use of the telephone to seek content clarification is not documented. However, NKS management judges it to be quite modest.

Cost analysis

The cost analysis consists of a summary of the direct course costs (total costs), a determination of the average cost per student (and the respective cost function) and finally the cost per student learning hour.

Total direct costs

We assume here that the unit production cost per E60 is the same as in the Norsk course which was £5.60. This enables us to separate fixed costs of development from variable cost of production for the video input.

Table CS 4.5 can be used to write down the total cost function TC = F + V x s. F represents the fixed, V x s the variable costs:

$$TC = F + V \times s$$

$$TC = £105\,006 + £69\,856 = £174\,862$$

Average cost per student

We can infer the unit cost (i.e. variable cost per student) :

For s = 638 we have

$$V = \frac{£69\,856}{638} = £109$$

Table CS 4.5: Summary of direct costs

Total direct costs	Based on actual enrolment
Number of students	638
Fixed costs	
Development costs print	81 311
Development costs video	23 695
Subtotal fixed	105 006
Variable costs	
Production costs print	19 151[a]
Production costs video	3 573
Subtotal production costs	22 724
Assignments	39 870
Mailing	5 187
Enrolment	2 074
Subtotal variable costs	69 856
Total direct costs	174 859

Source: NKS data; all costs in £'95 Note: a: this figure includes costs of bought-in print material equivalent to £ 17.85 per student. For 638 students this amounts to £ 11 389. This added to the £ 7762 from CS4.2 gives the £ 19151.

The total cost equation allows us to determine the average cost per student. TC = F + V x s can be transformed into AC = F/s + V.

For s = 638 we have

$$AC = \frac{£105\,006}{638} + £109 = £165 + £109 = £274$$

Evidently, if the number of students increases, e.g. to 1 000, then the average costs comes down to £120.

Average cost per successful student

Some 68% of students complete their assignments at NKS. They take public exams. For reasons of data protection, NKS is excluded from access to the success rate of their students in public exams. Hence the exact success rate is not known to NKS. If we take the completion rate at NKS as proxy for the graduation rate we get (based on the sample):

$$AC = \frac{£105\,006}{(638 \text{ x } 68\%)} + £109 = £351$$

The completion rate of 68% in this course can be considered as high. This may be partly due to the promotion candidates are likely to get if they have completed the course successfully.

Cost per student learning hour

The overall number of learning hours generated by the course were 700. Therefore we have:

$$\text{cost/SLH(course)} = \frac{£105\,006}{700} = £150$$

The overall cost per student learning hours provided for therefore is:

$$\text{cost/SLH(media)} = \frac{£105\,006}{102.5} = £1024$$

The ratio of the SLH provided for and those ones generated by the course is about 1/7.

The print input amounted to 9.5 UE (print) which is taken to provide for 95 SLH. The number of student learning hours the student spends using the video is 7.5 SLH. Hence we can calculate the cost per student learning hour associated with each medium:

$$\text{cost/SLH(print)} = \frac{£81\,311}{95} = £\ \ 856$$

$$\text{cost/SLH(video)} = \frac{£23\,695}{7.5} = £3\ 159$$

It should be recalled here that the videos for this course were not developed from the scratch for the course but consisted of edited versions of a live satellite transmission. In comparison with the cost per student learning hour video of the Norsk course (amounting to £20 835), costs here are quite small.

Case study 5

Post-graduate Diploma in Business Engineering at the FVL in Berlin/Germany

The Federation of Polytechnics for Distance Education (FVL: Fachhochschulfernstudien Verbund der Länder) is mainly based in the new states ('neue Länder') of the Federal Republic of Germany. It was constituted in 1994 at the initiative of the ministries of education of Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt, Thüringen and the Senate of Berlin. At the moment 19 higher education institutions of the six states participate in the FVL whose central agency is located in Berlin (Fernstudienagentur der FVL). Though predominantly operating in former East Germany, the FVL branches out to co-operate with partners in the old states ('alten Länder'[1]) like the Institut für Verbundstudien (IV in Hagen) and the Zenstralstelle für Fernstudien an Fachhochschulen (ZFH in Koblenz).

The objective of the FVL is to promote distance education in the participating states by developing courses in collaboration with the participating polytechnics. The organisational structure of the FVL consists of an administrative council, several professional councils and the agency.

The administrative council consists of representatives of the different polytechnics recruited from the professorial staff. It involves representatives of the federal ministry of technology and research (BMBF) as well as the research institute for distance education (DIFF). Its role is to plan projects, allocate funds and guarantee the equivalence of distance courses with the corresponding on-campus courses.

The professional councils (composed of academics of the participating institutions) are responsible for the courses. They have to set the curriculum for their course, decide about the selection of authors, the examination requirements and procedures and finally the evaluation of the courses.

The agency, located in Berlin and attached to the 'Fachhochschule für Technik und Wirtschaft' (i.e. Polytechnic for Technology and Economics), serves as an organisational interface between the member polytechnics. It combines the role of initiating new courses with responsibilities covering editorial issues as well as the production and distribution of materials. It also has the remit of facilitating the future use of multimedia.

[1] The expression 'alte und neue Länder' (old and new states) refers to the states being part of the Federal Republic of Germany before unification and after.

Business Engineering: description of the programme

The case study is about the Postgraduate Diploma in Business Engineering at the FVL, a five-semester programme for part-time students. The programme is very transparent in its attribution of student learning hours and contact hours. It combines a high percentage of face-to-face contact (25%) with print inputs for self-study (75%). The self-study time per week is designed to be 15 hours of self-study for 24 weeks per semester over five semesters (i.e. 360 hours per semester). In addition we have 96 hours of face-to-face teaching per semester.

Seminars are arranged every two to three weeks on a Saturday and include a one-week block seminar per semester. Up to now the teaching material is print based but inroads are planned into other media including videocassettes, CD-ROM and Internet. Teaching of the practical elements of the curriculum is concentrated in the seminars which are held at various polytechnics which provide the necessary laboratory facilities and computing facilities. The Internet is used to facilitate contact between students, between students and teachers, and between students and the administration. (The web site of the main agency in Berlin is www.fvl-agentur.de)

Table CS 5.1: overview over the course programme

Semester	Content	Hours of self study	Hours of seminar
1. semester	Business studies	78	12
	Accountancy	71	18
	Business informatics	140	48
	Economics	71	18
		Subtotal 360	Subtotal 96
2. semester	Business studies Accountancy	139	38
	Economics	71	18
	Business law	71	18
		79	22
		Subtotal 360	Subtotal 96
3. semester	Business law	62	14
	Management	138	36
	(area of specialisation[a])	160	46
		Subtotal 360	Subtotal 96
4. semester	Management	88	20
	(area of specialisation)	272	76
		Subtotal 360	Subtotal 96
5. semester	Dissertation / Exam		

Source: FVL; Notes: a: areas of specialisation include: marketing, production management, logistics, environmental management.

The programme requires in total 4 x 360 = 1 440 hours of self-study based on the study guides covering the four regular semesters. Then comes the examination semester where the student is

studying completely on his/her own. For this semester we may add to the 1 440 student learning hours another 360 hours for the dissertation and the exam preparations. In addition we have 4x 96 = 384 hours of seminars. Adding all this together we have a course related study time of 2 184 SLH.

Resource media: inputs and costs

Until now the media input of the programme has consisted entirely of printed material. It comprises 16 study guides per semester each of about 50 pages. The development costs of each guide was estimated to be £3 040 each. The study guides are revised and replaced on a rolling basis. For the sake of simplicity we will assume here that six batches of students (i.e. 1 500) will use the material unchanged and after this it is replaced.

Table CS 5.2: development and production costs of print

Type inputs and type of costs	number and cost of inputs per semester	number and cost of inputs per course
Number of units	16	64
Fixed costs of development		
author related	24 320	97 280
design related	24 320	97 280
subtotal	48 640	194 560
Variable cost of production and distribution		
unit cost of study guide	1.52	1.50
variable cost per student	24.34	96.00
total variable cost (s = 1 500)	36 000	144 000
Total cost of print	84 640	338 560

Source: FVL; all costs in £'97

Student support: input and costs

Unlike many other distance-learning institutions which base student support mainly on tutor-marked assignments, FVL bases student support entirely on face-to-face tutorials. The tutorial time amounts to about 25% of the total study time and is seen as crucial to the high graduation rate of the course.

Table CS 5.3: cost of tuition

	per semester	per course
Unit cost of tutor per hour	19	19
Number of hours	96	384
Total costs of tutorials	1 824	7 296
Variable costs of tutorials per student (s = 30)	61	243

Source: FVL; all costs in £'97

From the figures in tables CS5.2 and CS5.3 we can see that the total variable costs per semester therefore amount to £25 + £61 = £86 per semester and per course £98 + £243 = 341.

Cost analysis

The cost analysis determines total direct costs, average costs and the various parameters of cost per student learning hours.

The total direct costs

The total (direct) course costs are the sum of the fixed and the variable costs:

Table CS 5.4: total direct costs

	per semester	per course
Fixed cost	48 640	194 560
variable cost of production	36 000	144 000
variable cost of tuition	1 824	7 296
subtotal	37 824	151 296
Total	86 464	345 856

Source: FVL; all costs in £'97

Average cost per student

We can now derive the average cost per student per semester or for the whole programme. We assume that during the lifetime of the course 1 500 students follow the study programme.

$$AC = \frac{TC}{s} = \frac{F}{s} + V \Rightarrow$$

For the semester we get:

$$AC = \frac{£\,48\,640}{1500} + £\,85 = £\,32 + £\,87 = £\,119$$

For the whole course we get:

$$AC = \frac{£\,194\,560}{1500} + £\,341 = £\,130 + £\,341 = £\,471$$

The number of student learning hours generated per semester was 360 +96 = 456 hours.

$$\text{cost/SLH(semester)} = \frac{£\,48\,640}{456} = £\,107$$

However the whole programme generated 2 184 hours of learning altogether:

$$\text{cost/SLH(programme)} = \frac{£\,194\,560}{2184} = £\,89$$

Using the conversion convention that 50 pages of print generate on average 10 hours of student learning and given that the course was based on print as the only pre-prepared teaching resource, we have for the semester as well as for the programme:

$$\text{cost/SLH(media)} = \text{cost/SLH(print)} = \frac{£\,48\,640}{160} = \frac{£\,194\,560}{640} = £\,304$$

Effectiveness

The programme prides itself on a high graduation rate. Most of the students enrolled are working, and therefore studying part-time. The high graduation rate might be explained by the direct relevance the course is perceived to have for their future career: engineers might want to move into managerial positions and feel that they need to understand the economic issues better; those in managerial positions might feel the need to understand the technical side of the process better because of their economic implications.

Case study 6

‘Psycho-social aspect of nursing’: Carl von Ossietzky University Oldenburg

The centre in Oldenburg is part of the local university but has a remit to service students of the Fernuniversität Hagen in Lower Saxony (the Fernuniversität is located in North Rhine Westfalia; it has to be kept in mind that educational issues in Germany are under Länder jurisdiction). This arrangement gives them leeway to develop their own programmes.

The course has grown from a local initiative, which was developed within the context of a scheme funded by the federal government to promote ‘humanist psychology’. The centre contracted writers to write about the ‘psycho-social aspect of nursing’ (course title) to enable nurses to support patients in situations of distress. Even though the course was not free, nor part of a credit programme and participants received only a certificate, it attracted considerable interest. This was due to the fact that it covered an area generally neglected in the standard professional development programmes but of pressing importance in the field.[1]

Resource media: inputs and costs

Students were given six units of print material, each unit containing about sixty pages. Each unit was intended to be the focus during one month of the course. It required 15 hours of study time. This means that the self-study part of the course amounted to 90 student learning hours.

The initial funding under the ‘humanist psychology’ framework amounted to £6 800 and was almost entirely used to pay the authors to write the material. Using the standard assumption that 50 pages represent one unit equivalent (UE), the total material amounted to slightly more than seven UE and therefore, in its initial form, cost about £917/UE.

However, a significant feature of the course is that it has been regularly updated and renewed on a rolling basis. The costs for updating and maintenance were indicated at £3 400 in each year between 1990 to 1997. However, these costs include not only fixed costs of rewriting the course but also the variable costs of printing and semi-variable costs of administration and marketing.

[1] For more about the course concept see: Bernath U. and Fichten W., *Adaptation in distance education - new experiences from networking universities in Germany*, Open Learning, Volume 14, No. 1, February 1999 p. 45-50. For further Internet references see: http://www.uni-oldenburg.de/zef/literat/wwwveroe.htm

We can distinguish three phases during the lifetime of the course up to the time of writing: during the first years the course was drafted and the material written. In the second phase (1990 to 1992) the course was taught and run on an experimental basis at local level. Then from 1993 onwards the course has been adopted by a number of universities. The Centre for Distance Education at Oldenburg University would license the course to be taught by the contracting universities. The licence fee was £34 per student enrolled, for which in turn the Centre had to provide the set of six study guides to each student. Since the production cost per guide is unlikely to be higher than £1.70 per unit (or £10.20 per set) such contracts would generate the funds partly to recover the costs of the initial investment, partly to finance maintenance and further development.

Student support: inputs and costs

The face-to-face component of the course was high. Each month over the half year of its duration, corresponding to each topic, a weekend seminar was organised over two days for seven hours per day. The cost of the seminar can be inferred from the following breakdown of student fees and the attribution of the components to various cost drivers. (The cost attribution was made by the course manager.)

Table CS 6.1: Cost attribution of fees to different cost drivers

	Income	Costs	Cost (per seminar per student)	Cost per seminar[a]
Total fee per student	408			
Attributable to print		34		
Attributable to seminar		374	62	930
Administration and marketing		81	13.5	202
Tutorials		293	49	735

Notes: a: the calculation is based on the assumption of an average seminar size of 15; all cost in £'97.

The above table together with the information that we have on average 15 students per seminar allows us not only to estimate the cost per seminar but also the cost per hour for the tutorial, which is £731/14 = £52.50.

Costs and income

Besides the initial funding to help with the start, the course was intended to be self-supporting. Fees are set in a way to cover the seminar costs and to allow adapting and maintaining the course. The following table gives a summary of the development of the net costs. We treat the initial funding as sunk costs.

Table CS 6.2: cost and income development of the course

	Before	1993	1994	1995	1996	1997
Enrolment						
Oldenburg		30	40	40	40	40
Others		100	100	220	360	290
Oldenburg + others		130	140	260	400	330
Accumulated student no		130	270	530	930	1 260
Costs to Oldenburg						
Development and maintenance						
Development cost (Phase I 1986-89) treated as sunk cost	6 800					
Maintenance cost (Phase II: 1990-92)	10 201					
Maintenance cost (Phase III)		3 400	3 400	3 400	3 400	3 400
Added component:			10 201			
Subtotal Development + Maintenance	10 201	3 400	13 601	3 400	3 400	3 400
Presentation costs Oldenburg		11 221	14 961	14 961	14 961	14 961
Print cost (Oldenburg students)		306	408	408	408	408
Print cost (External students)		1 020	1 020	2 244	3 672	2 958
Subtotal production and presentation cost Oldenburg		12 547	16 389	17 613	19 041	18 327
Total cost to Oldenburg	10 201	15 947	29 990	21 013	22 441	21 727
Income to Oldenburg						
Income from fees from Oldenburg students		12 241	16 321	16 321	16 321	16 321
Income from licence to external students		3 400	3 400	7 480	12 241	9 861
Total income		15 641	19 721	23 801	28 562	26 182
Net income	-10 201	-306	-10 269	2 788	6 120	4 454
Accumulated net income		-306[a]	-10 575	-7 786	-1 666	2 788

Note: a: we treat the initial maintenance costs here as sunk costs; all cost in £'97.

The table indicates where the scale economies are lying: the course is taught in Oldenburg only to a small group of students, about 40 per year but sold to an additional 250 to 300 students per year. Each of those students pays £34 for the study pack. However, no costs are incurred in Oldenburg for teaching the course. Hence the £34 per student amount to £8 500 to £10 200 per year. Since the printing costs are likely to be considerably less (not more than £10.20 per set), the lion's share of this money can be re-invested and used to recover initial costs.

Cost analysis

The structure of the arrangement, which the Centre in Oldenburg has set up, is basically as follows:

The students‘ fee can be seen as consisting of two parts: the part attributable to cost of presentation (weekend tutorials) and the licence fee (i.e. £374 for presentation + £34 licence = £408 fees).
The licence fee is set in such a way that it allows for the partial recovery of development and maintenance costs. The licence fee for the whole printed material is £374 but the actual production cost of the printed material is £10.20 only. We therefore have a ‘profit margin’ of £23.80.

The biennial investment in maintenance, which completely updates the material, amounts to a yearly average cost of £3400. Hence an enrolment of 100 students would cover the ongoing maintenance and printing costs. Any enrolment above 100 would make it possible to recoup parts of the initial investment.

It is always difficult to apply the average cost formula to courses without definitive lifetimes, and where materials are updated on a rolling basis. We have elsewhere adapted the convention of assuming a notional life span of five years and treating the cost of maintenance as fixed costs. Applying this convention here we would get £17 000 as fixed costs of development for the whole of the printed matter. Each unit provides for 15 hours of learning (according to the learning logs of the participants). This leads to £17 000/90 =£189/SLH (Print).

Using the same assumption, treating the initial development costs as sunk costs and setting development costs at £17 000 (= 5 x maintenance cost) and using the actual cost the tutorials as unit costs, we get a lower limit estimate for the average cost per student:

$$AC = \frac{\text{Total cost}}{\text{Student number}} = \frac{£17\,000 + (£\,293 \text{ x } 1260)}{1260}$$

$$= \frac{£\,17\,000}{1260} + £\,293 = £13 + £\,293 = £\,306$$

If, however, we take the total cost of development and maintenance as costs into account and include the marketing and administration costs per student then we have:

$$AC = \frac{\text{Total cost}}{\text{Student number}} = \frac{£47\,600 + (£374 \text{ x } 1260)}{1260} = \frac{£47\,600}{1260} + £374 = £412$$

Case study 7

Domestic Violence and Sexual Assault: a course offered by the School of Advanced Nursing, Midwifery and Professional Health Studies at Anglia Polytechnic University/United Kingdom

The course was developed and taught by the School of Advanced Nursing, Midwifery and Professional Health Studies of the Anglia Polytechnic University. It was published as part of APUs Flexible Learning series[1].

The course is taught as part of the WIRE project. This project is an initiative of the European Association of Distance Teaching Universities (EADTU). The EADTU was founded 1987 (headquarters being in Heerlen, Holland) with the remit to foster co-operation between European distance teaching universities. British members are the Open University (OU) and the Open Learning Foundation (OLF). The latter is a consortium, in which a number of universities have pooled resources for developing distance-teaching material as well as providing advice on its implementation. Membership in the OLF also links all the participating universities to EADTU. It is via this link that Anglia Polytechnic University (APU) and other OLF members including Sunderland and De Montfort Universities participate in the WIRE project.

The remit of this particular pilot project is to explore the potential of new technologies such as ISDN technologies and the WWW. Such technologies allow universities to offer courses in different parts of Europe. However, students must have access to the respective technologies. Access points are provided in the EuroStudyCenters, many of them attached to the EATDU universities.

This module, Domestic Violence and Sexual Assault, developed at APU (jointly at Brentwood, Chelmsford and Cambridge), is addressed to healthcare and public-sector workers. The following EuroStudyCenters are involved: Antwerp and Leuven (Belgium), Kortrijg and Heerlen (Holland), APU Chelmsford, and Norwich Campus, De Montfort University and the University of Sunderland. If students follow the course and pass the assessment they are given 20 credits, transferable to any of the participating institutions.

[1] The full title is: L. Shipway (1996), Facilitating Survivors of Domestic Violence and Sexual Assault; Biological, Social and Psychological Aspects of Intervention, APU Flexible Learning.

Resource media: Inputs and costs

The teaching material provided consists of a printed text and an interactive hypertext edition based on this text.

Print

The textbook has about 150 pages. The first 100 pages contain the four teaching units each of about 25 pages, the remaining 50 pages consist of supporting articles. The four teaching units are made interactive by in-text questions and in-text activities.

The author was paid £2 000. No further compensation in terms of a reduction of teaching load was made. The time required to write the text amounted to 120 hours (i.e. 24 days of five hours a day). This would mean the cost of the author was less than £17 per hour. The estimate is conservative and does not include research time.

The time for editing and layout was estimated at 250 hours (i.e. 50 days at five hours a day).

Table CS 7.1: Fixed costs of development

Type of Inputs/costs	Number/amounts	Unit costs	Total costs
Number of students	75		
Print inputs UE[a]	3		
Development costs			
Author related[b]			2 000
Design related			2 175
Internet version[c]			5 500
Subtotal			9 675
Production costs			
Printing		3.50	263
Distribution		1.15	86
Subtotal		4.65	349
Total (s = 75)			10 024

Source: APU; Notes: a: UE (Unit Equivalent) a text of about 50 pages; b: the text is about 100 pages long; c: the text was re-edited with hyperlinks for Internet.

The Internet

An Internet version of the module was produced and made accessible (with code word) under the web address http://www.ion.anglia.ac.uk. It included the editing-in of hyperlinks and multiple choice self-assessment questions and various other features of computer assisted learning (CAL) to make the text interactive. These features also monitor student's progress: students can only move from one chapter to the next if they have completed a test.

The author was given a one-off payment of £5 500. The time required only for editing-in the hyperlinks requires about 16 working days of six hours per day: per page we have on the average six hyperlinks. To edit them in and to test them requires one hour's work per page. A text of 100 pages therefore requires 2 x 50 hours total or 16 working days at £200 a day. However, hyperlinks were only part of the editing treatment required.

Student support: inputs and costs

Several forms of student support were provided: a marked assignment, computer-mediated communication and videoconferencing.

TMAs and CMC

For assessment an assignment of not more than 4 000 words has to be completed. The marking time is about two hours per student. The support students are given for the assignment is provided via computer mediated communication (CMC).

Table CS 7.2: Cost of student support TMA & CMC

Type of support/personnel	No of hours	Cost per hour	Total cost	Unit cost (s = 75)
TMA[a]				
Senior lecturer	2	28	4 200	56
CMC				
1 x senior lecturer	64[b]	28	1 792	24
3 x senior lecturer	16[c]	28	1 344	18
Subtotal			3 136	42
Total			7 336	98

Source: APU; Notes: a: a TMA of 4,000 words; b: main tutor at 4 hours per week over 16 weeks; c: support tutors at 1 hour per week over 16 weeks.

All tutorial work is done by lecturers. The midpoint salary of a senior lecturer is £23 800. The lecturer is supposed to teach 550 hours per year. In addition a lecturer is supposed to spend 35% of the time in research. Neglecting the administrative duties, the lecturer then has to work 296 + 550 = 846 hours per year. This would give us the estimate of the cost per hour of £23 800/846 = £28 per hour.

The main cost driver of CMC is the cost of the tutor. The server, computers and software are part of the infrastructure provided by the EurostudyCenters and should not be attributed as direct course costs.

It was estimated that the main tutor (in this case a senior lecturer and at the same time the author of the module) would be required for four hours a week for 16 weeks to lead the CMC discussion. Three other senior lecturers took part one hour a week.

Videoconferencing

Five videoconferences were to be held. However, each such conference demands about one extra hour of preparation involving teaching staff as well as technical and support staff. Two guest speakers have been invited.

Table CS 7.3: Videoconferencing

Inputs	Cost per hour	No of hours	No of sites	Total costs
Depreciated equipment cost[a]	6.5	10	8	520
Line cost	25	10		250
Personnel cost				
3 lecturer	28	10		840
1 guest speaker	45	2		90
1 support staff	8.5	10	8	680
Total				2 380

Source: APU; Notes: a: depreciation over five years at a usage rate of 51 weeks, 5 days a week and 3 hours per day.

A video system is available at a wide price range. It was indicated that the system used in APU costs about £20 000 + VAT. We entered the cost here as £25 000. The initial cost has been depreciated here over three years assuming a usage rate of 765 hours per year (i.e. 51 weeks five days a week for three hours).

We may calculate the unit cost due to videoconferencing as £2380/ 75 = £31.

Cost analysis

The cost analysis includes an estimation of the projected total direct costs of the course, the average cost (including the average cost function) and the various costs per student learning hours.

Total direct costs

Tables CS 7.1 to CS 7.3 allow us to tease out the total (direct) costs of the course.

Table CS 7.4: Total costs

Type of costs	Subtotals at s = 75
Fixed costs	
Development print	4 175
Internet	5 500
Subtotal	9 675
Variable cost	
Production cost (print)	349
Student support	
TMAs	4 200
CMC	3 136
Videoconferencing	2 380
Subtotal variable	10 065
Total cost	19 740

Source: APU

Average cost per student

The average cost per student are the total cost divided by the number of students. We have:

AC = £19 740/75 = £263.

Tables CS 7.1 to CS 7.3 allow us to tease out the aggregate unit costs. We have £4.65 for production and distribution, £98 for support by computer mediated conferencing and tutor marked assignments, and finally £31 due to videoconferencing. This amounts to £134 as aggregate variable cost. This allows us to determine the average cost function:

$$AC = \frac{£\,9\,675}{75} + £\,134 = £\,129 + £\,134 = £\,263$$

It has to be recalled that the course was experimental in a double sense: it experimented with a combination of new technologies and it experimented with international co-operation in higher education. The high average costs are to a large extent due to the small number of students.

Cost per student learning hour

The course is a 20 CAT point course and can be rated as requiring 200 student learning hours. Hence, the cost per student learning hour of the course as a whole is:

$$\text{cost/SLH(course)} = \frac{£\,9\,675}{200} = £\,48$$

Since the printed text is 150 pages long, it is rated to be equivalent to 30 hours of study time. The cost per student learning hour provided for by print is:

$$\text{cost/SLH(print)} = \frac{£\,4175}{30} = £\,139$$

However, it could be argued that the interactive features of the text (in-text questions, in-text activities) increase the study time. An inspection of the numbers of questions and activities suggest that the study time might be increase by three hours per unit (i.e. 12 hours altogether) if the students follow the interactive features. Since the study time increases, the cost per student learning hour falls:

$$\text{cost/SLH(print)} = \frac{£\,4175}{42} = £\,99$$

The same argument applies *a fortiori* for the hypertext version to which even more interactive features have been added. Due to control features, which do not allow the student to skim the text, it is more likely that interactive features in fact increase study time. (In fact, considering the number of hyperlinks included, the study time would increase by 10 hours if students attend to each hyperlink for one minute only.)

Since the hypertext version is based on the printed text, the cost of the hypertext version should include at least the author-related costs.

$$\text{Cost/SLH(hypertext)} = \frac{£\,7\,500}{42} = £\,179$$

The cost per student learning hours CMC cannot be estimated. Though we know the costs, we do not know the study time created.

The cost per student learning hour videoconferencing should be distinguished from the average cost per student of videoconferencing. The cost creating five hours of videoconference has been £2 380 hence:

$$\text{Cost/SLH(videoconference)} = \frac{£\,2\,380}{5} = £\,476$$

Case study 8

A DEUG level I philosophy course offered by the distance teaching centre at the University of Rheims

The course is taught by the centre of distance education at the University of Rheims ('centre de télé-enseignement universitaire' or CTU). The CTU Rheims is part of the inter-university federation of the distance-education centres of the east of France called FIT-Est (féderation universitaire d'est)[1].

FIT-Est is a group of distance teaching centres attached to a number of universities which have pulled resources together to provide distance-education courses. Each university provides facilities, administrative and technical support and assigns teaching staff to the centre. The federation is intended to increase economies of scale and, by specialising at each centre on a specific subject area, improve efficiency. The universities participating in this federation are: Dijon (French literature), Nancy (English), Rheims (philosophy and psychology), Strasbourg (German, sociology, and applied linguistics) and Besançon (arts, law, and mathematics).

Budgets of the distance teaching centres

However, there is no budget for course development besides the staff time assigned to the centre. This means that the output of the centre (in terms of teaching material produced) must be costed in teaching time. Therefore it is necessary to determine the cost per hour of a staff member.

The calculation of the salary per hour proceeds from the assumption that 2/3 of the working hours are considered as normal hours and 1/3 as complementary hours. (This is due to the fact that the ministry of education is financing 2/3 of teaching time through teaching positions and 1/3 through supplementary hours.) A lecturer receives £51 440 for 128 hours teaching. However, 1/3 of the salary is for research. Therefore the salary for teaching amounts to 2/3 x £51 440 = £34 293. This would amount to £268 per hour. According to the above assumption only 2/3 of the hours are normal hours but 1/3 is paid as part-time salary of £41 each. If we weigh this accordingly we would get (2/3 x £268) + (1/3 x £41) = £192 as average per hour salary paid at the centre.

1 This case study draws from Sandoss Ben *Abid (1997) Analyse coût-efficacité du centre de télé-enseignement universitaire de Bourgogne* Memoire de DEA, of IRÉDU Université du Bourgogne. The thesis studies the CTUs of the FIT-EST and was written under the supervision of Prof. F.Orivel. It was part of the co-operation of irédu and IRFOL. An interview allowed me to tailor the information collected to the needs of my research. I thank both Prof. Orivel and Sandoss Ben Abide for their co-operation.

The calculation of the salary per hour is essential since it is basically the lecturer time freed to work at the centre, which constitutes the development budget of the centre. The lecturer is the person developing the printed material as well as the audiocassettes. The convention for cost attribution is that one 'unité d'enseignement' is worth 36 hours, be it print or cassettes.

Resource media: inputs and costs

Table CS 8.1 shows the degree structure and the distribution of contact hours to degrees. Since 400 hours of staff time represent the total budget of the CTU for the DEUG 1 and this staff time is used to develop 11 teaching modules we can estimate the development cost of one module by the formula: (400 x £192)/11 = £76 800/11 = £6 982.

Table CS 8.1: CTU Rheims/philosophy

Level	Contact hours	Student learning hours	Modules	Material provided
DEUG 1	400	600	11	9 print/1 audio[a]/1 print+audio
DEUG 2	400	600	11	9 print/1 audio/1 print+audio
Licence	375	563	7	6 print/1 print+audio
Maitrise	100	150	4	3 print/1 print+audio

Source: IRÉDU; Notes: a: the total audio input consists of five C60 cassettes.

The study material provided for DEUG 1 Philosophy consists of 11 teaching units or modules (unités d'enseignement), of which nine modules are delivered completely in print, one module in form of audio cassettes and one module as a combination of print and audio material.

Print

The nine modules contain about 160 pages each. We do not know the size of the print input, which goes with the mixed module. But since four C60 cassettes cover a module of 160 pages, one C60 cassette can be taken as equivalent of 40 pages, reducing the print input in the mixed module to 120 pages. The total amount of print input therefore is (9 x 160) + 120 =1 560 pages. Standardising the print input in terms of unit equivalents of 50 pages each we have: 1 560/50 = 31 UE.

However, since we have nine print modules and one combining print with audio, multiplying with nine would be too small a factor and ten too big since the module comprises an audio element. I propose to add 0.75 as a weighing factor accounting for the print input of the print + audio module.

Therefore the total cost of the printed material therefore can be estimated as

9.75 x £6 982 = £68 075

This means that the cost per unit equivalent (UE) is:

Cost/UE (print) = £2 196

Audio Cassettes

The total input of audiocassettes amounted to five cassettes of one hour. The audio input covers 1.25 modules. The total cost of development of the audio material therefore is

1.25 x £6 982 = £8 728

This means that the cost per unit equivalent audio is:

Cost/UE (audio) = £1 746

Since we have 11 unités d'enseignement in DEUG 1, to each of them an average development budget of 400 hours/11 = 36 hours has to be attributed. Hence, the total cost per unité is

36 x £192 = £6 912

Production and distribution costs

The figures above cover more than the costs of development. They include production cost and support cost. However, as the course material consists of photocopied spiral binders most of the cost is for staff time and covered out of the budget described.

The unit cost of production for the study material was estimated to be £60 for production (print and audio) and £15 for distribution. Neglecting the cost of student support we have a variable cost per student of £75.

Student support

There are no standardised arrangements for student support. What support is given comes from the time budget already described. If teachers are more active in supporting students they must produce their module in a shorter time.

Cost analysis

The cost analysis estimates total direct course cost, average costs and the parameters of cost per student learning hour.

Total course costs

The total course costs have been calculated as (400 x £192)= £76 800

Average costs

Average costs are the total costs divided by the number of students. 100 students were enrolled. Since the course has no specified lifetime but is revised on a rolling basis, I assume a lifetime of five years and neglect any maintenance cost in between. In this case we get:

$$\text{AC} = \frac{£\ 76\,800}{500} + £\ 75 = £\,154 + £\ 75 = £\ 229$$

Cost per student learning hour

The overall number of student learning hours was taken to be 600. This estimate is based on the fact that in the conventional course we have 400 contact hours of teaching. The study time of students was estimated on the basis that two-thirds of the student learning time in the conventional system were contact hours. Consequently we get:

$$\text{Cost/SLH(course)} = \frac{£\ 76\,800}{600} = £\,128$$

If we add the study time directly created by the media input we have 310 student learning hours from print and 5.25 from audio, i.e. 315.25. Hence:

$$\text{Cost/SLH(media)} = \frac{£\ 76\,800}{315} = £\ 244$$

The cost for 50 pages of print (1 UE) has been determined as £2 196/UE. Since one UE creates 10 hours of study, we have:

$$\text{Cost/SLH(print)} = \frac{£\ 2196}{10} = £\ 220$$

The cost per student learning time through audio media has already been calculated:

Cost/SLH (audio) = £8 728/5 = £1 746

$$\text{Cost/SLH (audio)} = \frac{£\ 8\,728}{5} = £\,1\,746$$

The close similarity between the costs per unit equivalent for audio and print reflects the fact that the cost driver is essentially the time of the author. Production costs, which generally impact strongly on cost per student learning hour for audio, are virtually ignored here as there is no specific budget for production.

Case study 9

Using videoconferencing at the Engineering Faculty of the Politecnico di Milano/Italy

The Politecnico di Milano[1]consists of two Faculties: the Engineering Faculty with about 30 000 students and the Architecture Faculty with 15 000 students.

The large number of students enrolling at the main campus ('Leonardo da Vinci') in Milano led to the decision in the early 1990s to decentralise the university by adding another campus at Como, about 40 km from Milan. Further campuses were added in Lecco, Cremona and Mantova.

In order to use the same staff without losing valuable staff time for travelling, a distance-teaching system based on videoconferencing was designed. Prof. Brofferio (1998) describes the system as having three levels:

- "the classroom, with audio-visual equipment (TV cameras –TVC and TV displays – TVD), computers (PC, CD-ROM, etc.) and other facilities as videotape recorder (VTR) connected by the classroom matrix switch for source destination selection and external communication;
- the intracampus network, based on a star analogous to commercial TV quality connection for intracampus communication and intracampus interfacing (campus switch);
- the intercampus network, which uses an FM radio and the public telephone network ISDN."

In this case study we do not report the cost of a specific course but describe the cost structure of videoconferencing. The cost structure of videoconferencing is similar to the cost structure of lecturing in so far as that the cost per videoconference per hour is known, the cost of a course can be inferred from the number of contact hours the course requires. Hence we report after a discussion of the general cost structure of videoconferencing the cost data for the Politecnico di Milano and estimate the cost per hour of videoconferencing as well as the average cost per student in videoconferencing based on these data.

[1] This case study is based on personal communications with Prof Brofferio (email and videoconference) and his article S.C.Brofferio *A University Distance Lesson System: Experiments, Services, and Future Developments* in: IEEE Transactions in Education, Vol41 NO 1, February 1998.

The cost structure of videoconferencing

Videoconferencing is designed to allow lecturing at a distance, even at different sites simultaneously. There are two types of set-up of videoconferencing: the symmetrical (or peer) case and the asymmetrical (or master/slave) case. In the symmetrical case the sending and receiving stations are all identically equipped for sending as well as receiving.

In the asymmetrical case only the teacher station is equipped for sending and the other stations are equipped only for receiving. The asymmetrical setting is cheaper in terms of equipment requirement but lacks flexibility. In any case, to calculate the cost of one hour of videoconferencing we need to know: (i) the depreciated costs of equipment per hour or DEC (ii) the cost of the technical support per hour or TSC, (iii) the line costs per hour or LIC, (iv) the lecturer cost per hour or LEC and finally, (v) the number of sites to be connected or S.

The depreciated equipment cost is the initial cost depreciated over the lifetime of the equipment, i.e. divided by the number of hours the equipment is in use. Though the initial costs are quite high, the cost impact on the cost per hour depends to a large extent on the rate of usage.

The line costs vary with the quality requirement. The quality which can be achieved depends on the type of pictures to be sent (e.g. fast moving, multicoloured), the type of connections used (e.g. switched circuits or packet switching) and the codec qualities (i.e. the compression algorithms available). Very common are ISDN lines of 128Kbps or 384 Kbps.

The symmetrical or peer case

In the symmetrical case with two sites (S = 2) the cost per hour of teaching using a videoconference system (VCS) can be calculated as:

C/SLH(VCS) = (DEC + TSC) x 2 +LIC + LEC

This means that we have at each site equipment costs and costs of technical staff. We have one line to pay for and one lecturer.

To find the average cost per student we only have to divide the cost per student by the number of students N:

$$(2) \qquad AC/SLH(VCS) = \frac{C/SLH(VCS)}{N} = \frac{[(DEC + TSC) \text{ x } 2 + LIC + LEC]}{N}$$

Since N, the number of students, can be considered as a product of the number of sites S and the average number of students per site G, we have for S = 2, N = 2 x G:

$$AC/SLH(VCS) = \frac{[(DEC + TSC) \text{ x } 2 + LIC + LEC]}{2 \text{ x } G}$$

(3)

$$= \frac{[DEC + TSC + \frac{(LIC + LEC)}{2}]}{G}$$

The general case S=>2 is:

C/SLH (VCS) = (DEC + TSC) x S + LIC x (S – 1) + LEC

$$AC/SLH(VCS) = \frac{[(DEC + TSC) \text{ x } S + LIC \text{ x } (S\ 1) + LEC]}{S \text{ x } G}$$

(5)

$$= \frac{[DEC + TSC + \frac{LIC \text{ x } (S\ 1)}{S} + \frac{LEC}{S}]}{G}$$

In fact, since (S-1)/S = 1-(1/S) approaches 1 when S gets larger, we may simplify the above formula and write:

(6) $$AC/SLH(VCS) = \frac{[DEC + TSC + LIC + \frac{LEC}{S}]}{G}$$

This formula reflects the fact that the average cost per student declines if the number of sites increases.

The asymmetrical case

In the asymmetrical case we have sites which are differently equipped. Generally they are not equipped with the same sending facilities and do not require a sophisticated teacher station. Consequently the depreciated equipment cost (SEC) in the slave classrooms are lower.

We introduce immediately the general case. At all sites we require technical support (hence TSC x S). At all but one site we have to account for the depreciated equipment costs for the slave classrooms. This is the same number as the number of lines which link the teacher station to the other classrooms. The lecturing costs and the depreciated cost for the master classroom are to be counted only once:

(7) C/SLH(VCS) = TSC x S + (SEC +LIC) x (S – 1) + LEC +DEC

The average cost per student is:

$$8) \qquad AC/SLH(VCS) = \frac{[TSC + (SEC + LIC)\,x\,\frac{(S\ 1)}{S} + \frac{(LEC + DEC)}{S}]}{G}$$

The cost behaviour can be seen better if we assume that S is big and therefore (S-1)/S = 1-(1/s) ≈ 1

$$(9) \qquad AC/SLH(VCS) = \frac{[TSC + SEC + LIC + \frac{(LEC + DEC)}{S}]}{G}$$

The above analysis suggests an interesting conclusion can be drawn. We might be interested to know in which case videoconferencing promises lower average cost per student than conventional. The average cost of a lecture being the cost of the lecturer and the number of students in the group:

(10) AC/SLH(lecturing) = LEC/G

We are interested to know for which case the following relationship applies:

(11) AC/SLH(VCS) < AC/SLH(lecturing)

We demonstrate the case only for the symmetrical case. For S = 2 and using (3) we get:

$$(12) \qquad \frac{DEC + TSC + \frac{(LIC + LEC)}{S}]}{G} < \frac{LEC}{G}$$

Since G can be cancelled, it follows that the break-even point is independent of the group size. From (12) we can derive a criterion for the lower average cost of videoconferencing as compared to lecturing:

(13) 2 x DEC + LIC LEC – 2 x TSC

The general case follows from the substitution of (6) into (11) and yields using 1-(1/s) ≈ 1:

(14) DEC + LIC < LEC -TSC

The formula allows us to make the following observations: for videoconferencing to achieve lower average costs, the difference between the cost of technical support staff and the cost of the lecturer must be substantial. On the other hand, line costs and depreciated equipment costs should be low. In order to achieve low depreciated costs of equipment a reasonably high usage rate is essential.

Costs of videoconferencing at the Politecnico di Milano

The costs do not refer to a specific course. However, general information on equipment cost, depreciation time, line cost and personnel costs were obtained which allow us to calculate cost per hour of videoconferencing as well as the average cost per student of videoconferencing.

Cost of equipment

The equipment costs fall broadly into two categories: costs of display equipment and network related equipment. The display equipment includes the equipment of the teacher station. A summary of equipment costs is presented in table CS 9.1. It was suggested that the equipment costs should be depreciated over five years at a usage rate of 1 300 hours per year (5 years x 26 weeks per year x 5 days per week x 10 hours per day =6 500 hours).

Line costs

For intercampus connection, ISDN lines were used. The line costs depend on bandwidth: 128 Kbps cost £17 per hour and 384 Kbps cost as much as £52 per hour.

Personnel costs

The personnel costs consist of costs for technical support and the cost of the lecturer. The cost of technical support per hour was specified as £13. The cost of the lecturer seems to depend on the number of students taught: £1 per student. Since the average group size was specified as varying between 25 and 50 students, we assume that the cost of a lecturer is about £38. This allows us to calculate the cost per hour of videoconferencing.

Cost analysis

The cost analysis includes the calculation of the cost per student learning hour and the average cost per learning hour per student and a comparison between the average cost per student of videoconferencing to the average cost per student of lecturing.

Table CS 9.1: Equipment costs

Type of equipment	costs
Display Equipment	
Overhead camera	1 672
Teacher Tracking Camera	1 003
Monitor 11"	1 003
Backprojectors (n.2)	14 716
Video Matrix (16:4)	468
Presentation manager	836
PC+VGA/PAL	1 338
Audio Mixer	468
Wireless Microphone	334
Sliding Blackboard	1 003
Subtotal	22 841
Network/connections	
Videodec (compression lab)	53 512
Videodec (Aethra)	6 689
Inverse Multiplexer(Teleos)	3 344
Subtotal	63 545
Total	86 386

Source: Politecnico di Milano

Cost per student learning hour
Depreciating the equipment cost over five years at the indicated usage rate we get:

$$DEC = \frac{£86\,386}{6\,500} = £13$$

Therefore (using (1)) we get:
Cost/SLH (VCS) = (£13 + £13) x 2 + £17 + £37 = £106

If we require higher bandwidths (384 Kbps at £52) we get:
Cost/SLH (VCS) = (£13 + £13) x 2 + £52 + £37 = £141

If more than four sites are linked we get, other things being equal, the following figure:
Cost/SLH (VCS) = (£13 + £13) x 4 + £17 + £37 = £158

Average cost per student
Using equation (3) and the above data and a group size of G = 30, we get:

$$\text{AC/SLH(VCS)} = \frac{[£13 + £13 + \frac{(£17 + £37)}{2}]}{30} = \frac{[£26 + £27]}{30} = £1.77$$

Higher line cost increases average costs. Using the 384 kbps rate at £52 per hour, we get:

$$\text{AC/SLH(VCS)} = \frac{[£13 + £13 + (£52 + £37)/2]}{30} = \frac{[£26 + £44.5]}{30} = £2.35$$

However, increasing sites reduces average costs (using (5)):

$$\text{AC/SLH(VCS)} = \frac{[£13 + £13 + (3/4)\text{ x }£17 + (1/4)\text{ x }£37]}{30} = \frac{[£26 + £12.75 + £9.25]}{30}$$

$$= \frac{£48}{30} = £1.6$$

Cost comparison with lecturing

We may use the above criterion to determine if under this condition videoconferencing achieves lower average cost per student than conventional lecturing. The above condition for S = 2 was:

DEC + LIC < LEC –2 x TSC

13 + £17 < 37 – 2 x 13 this is equivalent to 30 < 11 which is not the case

For bigger S the condition is only

DEC + LIC < LEC – TSC

But even then 13 + £17 < 37 – 13 this is equivalent to 30 < 24 which is not the case even independent of the number of sites. To argue for the use of videoconferencing as opposed to lecturing we would have to take account of the opportunity savings of not having to travel.

Case study 10

The Virtual Seminar: an online course for professional development in distance education offered as joint venture by the University of Maryland University College and Oldenburg University

The Virtual Seminar on Professional Development in Distance Education was held for the first time in 1997. It was presented as a joint project by the Centre for Distance Education and the Institute for Distance Education of the University of Maryland. The intention of the seminar is to use modern technological means (Internet/WWW) to bring professionals in distance education into a discussion with acknowledged experts in the field. The delivery method uses WWW based presentations together with on-line computer mediated communication (CMC) conducted over the Internet via a Netscape browser. Since net access is free for the Centre for Distance Education (through its membership of the Deutsches Forschungsnetz) as well as the Institute for Distance Education of the University of Maryland, the costs incurred by the two teaching institutions are comprehensively stated in the following table.[1]

Table CS 10.1: the First Virtual Seminar

Cost	Description of cost driver Virtual Seminar 1997
18 600	project development, project management and seminar moderation (2 persons)
4 960	two laptops for seminar leaders in Germany and Maryland for 'just-in-time' team teaching
9 300	technical assistance and hypernews[a] administration
7 440	four internationally renowned experts on open and distance learning (30hrs/week, plus their participation in the external evaluation)[b]
3 100	external evaluation
6 200	several: including two separate face-to-face meetings for the German and the US participants, internal evaluation, a presentation on the 18th ICDE conference in Pennsylvania, costs of final report
49 600	Total

Source: Fernstudienzentrum Oldenburg; all costs in £'97 ($1 = £0.62) Notes: a: The software development uses Hypernews™ which is an Internet freeware; b: the experts were on standby for one week. Hence, though the mode was basically asynchronous (CMC), the feedback time was generally shorter than 24 hours.

[1] A comprehensive documentation of the 'virtual seminar' is available in Bernath, Rubin 1999

ICDE and AT &T sponsored the first Virtual Seminar from funds to support international projects in distance education, which would make use of the new communication technologies.

To make it into a sustainable even self-supporting seminar the costs had to be reduced substantially. This was largely possible since the second edition of the seminar could profit from the development costs invested for the first one. This applies to the software development based on Hypernews, and also applies to the cost of the four international experts. Since the same experts were involved for a second time fewer preparatory meetings (concerning content as well as management issues) were necessary.

Table CS 10.2: the 2nd Virtual Seminar

Cost	Description of cost driver Virtual Seminar 1998
6 200	project development, project management and seminar moderation
3 100	technical seminar management and assistance based on Hypernews™
3 720	four internationally renowned experts on ODL (30hrs)
3 100	administration
16 120	Total

Source: Fernstudienzentrum Oldenburg; all costs in £'97 ($1 = £0.62)

There were 44 participants from 16 countries. The seminar was addressed to distance education professionals working in higher education. Each participant/institution had to pay £360 for the seminar. It was felt that for some institutions, especially in developing countries and the countries of Eastern Europe, this proved to be a too expensive. It was felt that a sort of scholarship system should be arranged for those cases.

The course was designed to take in 45 students whose fees would have covered the cost almost exactly.

Cost analysis

The first seminar had higher costs than the second. In order to differentiate the seminar's development and running costs we reclassify the costs according to a simple principle. We illustrate the principle in the case of management costs: during the second seminar, management costs were only £6 200. The joint management costs for developing and running the course have been £18 600. We break down these costs into £6 200 for running the seminar and genuine management related development costs of £12 400.

The application of this principle leads to the synopsis given in table CS 10.3.

The reduction of average cost from 1997 to 1998 signals that there is still a potential for scale economies. If the variable cost per year can be kept stable at £13 020 or £289 per student, then a repetition of the seminar for another three times would decrease average costs roughly to £400.

The commitment of participants in terms of study time was specified as about 80 SLH. The only medium used was computer-mediated communication or computer conferencing. Since we want to estimate the cost of the teaching process conducted over the Internet, we ignore the fixed costs of development and look at the cost of teaching and supporting the teaching process only.

Table CS 10.3: Synopsis of costs (1st and 2nd Virtual Seminar)

	1996	1997	1998
Management	12 400	6 200	6 200
Hardware related	4 960		
Software related	6 200	3 100	3 100
Content development and teaching	3 720	3 720	3 720
Subtotal (running costs)		13 020	13 020
Evaluation		3 100	
Conference & other		6 200	3 100
Subtotal (per year)	27 280	22 320	16 120
Total			65 720
No of students		45	45
AC		1 102	730

Source: reclassification of cost drivers from tables CS 10.1 and CS 10.2

The cost drivers are the personnel costs of management teaching and technical support. Table CS 10.3 indicates these costs as £13 020: half of them are management costs, a quarter teaching costs and a quarter relate to technical support. Given that the overall number of student learning hours was 80, the cost of conducting and supporting a computer mediated teaching process at a distance amounts to £260.

$$\text{Cost/SLH(CMC)} = \frac{£13\,020}{80} = £163$$

Case study 11

A law degree offered by the Catalan Open University in Barcelona/Spain

The 'Universitat Oberta de Catalunya' (UOC) has been in operation only since 1995. It was legally approved by the Catalan government in April 1995 and went into operation in the same year. Its remit is to offer distance education to the population of the region taking into consideration its specific linguistic and cultural needs. It was constituted as a foundation. The regional government of Catalunya managed to co-opt three private but public-oriented corporations into the foundation: the Federation of Chambers of Commerce, the regional Radio and TV Corporations and the Savings Banks Federation. However, the government of Catalunya is the major shareholder of the foundation with 75% of the total. The three foundation members contribute in ways specific to their profile: the Federation of Chambers of Commerce provides support centres for local students, the TV and Radio Corporations assist in media production, and the Savings Banks Federation offers financial loans to buy the required equipment.

It was stressed that UOC is constructed as a private university whose staff members are not civil servants. However, the Generalidad (i.e. the government of Catalunya) nominates the Rector who in turn nominates his team.

It is worth noting that staff recruitment is not only from universities but also from industry (e.g. a senior manger from an IBM research lab was recruited). If in full operation the UOC intends to operate with not more than 10 full-time academic staff members. Though the university is private, it is obliged to reinvest profits and not to enrich individual or private shareholders. It can also draw support from the traditional university sector so that UOC students have access to other university libraries. Arrangements to share laboratory facilities are envisaged.

The law course: Llicenciatura en Dret

The stated objective of the course is to enable students to exercise the law professions, understand and know how to apply the law and acquire an adequate proficiency for the different levels of specialisation within the profession.

The course requires as a minimum four years full-time study and carries 300 CAT points. Of the 300 credits 228 are core credits, 36 can be taken from a choice of options and again 36 may be chosen from a non-related academic area. Each semester between five and seven modules are studied, each of which carries on the average of six CAT points. The CAT value determines the print input (1 CAT is supported by 50 pages print) and in turn the development budget for the semester since the cost for developing a module is fixed.

To state the important benchmark relationships explicitly:

Course = 300 CAT = 50 modules or 1 module = 6 CAT = 6 x 50 = 300 pages

The pacing is such that no student is allowed to be dormant in the system for more than a year.

Access conditions vary. In principle an equivalent of a British A-level (Batxillerat) is required. However for students older than 25 years professional experience can also be taken into account.

Table CS 11.1: the law course: credit structure

		No of modules	No of credits
Semester	1	6	29.5
Semester	2	5	32.5
Semester	3	7	41.5
Semester	4	7	42.5
Semester	5	6	34.5
Semester	6	7	41.0
Semester	7	6	38.0
Semester	8	6	40.5
Total		50	300

Source: UOC; all costs in £'97 (at rate £1 = 248.76 PTA)

Resource media: inputs and costs

We indicated that soon after the UOC was constituted, it started to operate. The development of the first course modules was completed under considerable pressure. Pilot versions of the material for 100 students were tried before the course was opened to subscription. The maximum number of students to be enrolled in the course as a whole is 600. The production and development for a course of 30 CAT points is about nine months.

The only medium used for the time being is print. It is, however, planned to operate the whole university over the Internet. It is suggested that this would reduce considerably production costs and increase the efficiency of student support. Development costs would largely be the same as long as one limits oneself to text-based forms of presentation. At the time of the collection of the data, however, this process was not completed and the only medium used for teaching was print.

Table CS 11.2 summarises the development and production budget per semester. There is no clear separation between design cost (fixed) and variable print costs. Since, however, the number of students in a semester is quite limited, we consider the costs largely as fixed costs of development.

Table CS 11.2: Print: inputs and costs/semester

Type of input	Amount	Cost per module	Total cost
Module	6	20 100	120 600
Author related		6 030	36 180
Design & production related		14 070	84 420

Source: UOC; All costs in £'97 (at rate £1 = 248.76 PTA)

The percentage of the development cost which goes to the author is about one-third while two-thirds are design and production related.

Since we have standardised budget allocations the information in table CS 11.1 is sufficient to determine the development costs of the law course as a whole. The total development and production cost amount to £1 005 000 per course. Per semester they are on average £120 600.

Table CS 11.3: print : input and costs per course

		No of modules	No of credits	Cost per semester
Semester	1	6	29.5	120 600
Semester	2	5	32.5	100 500
Semester	3	7	41.5	140 700
Semester	4	7	42.5	140 700
Semester	5	6	34.5	120 600
Semester	6	7	41.0	140 700
Semester	7	6	38.0	120 600
Semester	8	6	40.5	120 600
Total		50	300	1 005 000

Source: UOC; all costs in £'97 (at rate £1 = 248.76 PTA)

Student support: inputs and costs

There are two types of support given to the student: (i) the academic support provided by a tutor and (ii) the more general support given by a counsellor.

Support by the tutor

Student support is based on correspondence and marked assignments. There are no face-to-face tutorials. (In future the tutoring is intended to be done via the Internet.) The number of assignments is not fixed. The tutors determine their number. Consequently tutors are not paid by assignment but

employed per semester. They have a markedly responsible role since it is also the tutors who assess students. The group size per tutor is limited to 50.

The cost of the tutor per semester is determined by the following formula:
Cost of tutor per semester = base rate + variable rate x no of students x CAT value of module
= £60 + (£4 x 50 x 38)
= £7 660

Support by the counsellor

Further support is given to student through counsellors: counsellors cater for 75 students and are paid per semester according to the following formula:
Cost of counsellor per semester = base rate + variable rate x no of students
= £502 +(£17 x 75)
= £1 777

As table CS 11.4 indicates, this implies a variable cost per student due to support of £178.

Table CS 11.4: Student support: inputs and costs

	Group size	CAT points	Total cost per semester	Unit cost per semester
Tutoring costs	50	38	7 660	153
Counselling costs	75	n/a	1 777	24
Total			9 437	177

Source: UOC; all costs in £'97 (at rate £1 = 248.76 PTA)

Cost analysis

We base the cost analysis on cost per semester. The cost analysis contains an estimation of average cost per student (per semester) and of cost per student learning hour.

Average cost per student

The average number of students can only be estimated since at the time of the data collection only part of the programme was in operation. The maximum number of students to be admitted will be 600. This would mean, that there are around 75 students in one semester.

No specification is made about the lifetime of a course. We assume that the lifetime will be five years and ignore maintenance costs. For five years we would have 375 students studying the same course material. Then we have:

$$AC = \frac{£\,120\,600}{375} + £\,178 \Rightarrow$$
$$AC = £\,322 + £\,178 = £\,500$$

Cost per student learning hour

The course carries 300 CAT points, which is considered to be equivalent to 3 000 hours of student learning. The average number of CAT points per semester is 38, which gives us an equivalent of 380 student learning hours. Since 1 CAT represents 10 SLH and is taught by an equivalent of 50 pages of print (i.e. one UE), the cost/SLH(semester) and the cost/SLH(print) are identical. Therefore we get:

$$\text{cost/SLH(print)} = \frac{£\,120\,600}{380} + £\,178 \Rightarrow$$
$$\text{cost/SLH(print)} = £\,317 + £\,178 = £\,495$$

Summary table of case studies Currency: Sterling

	SLH	$AC = \frac{\text{Fixed costs}}{\text{Student numbers}} + \text{Unit cost}$	C/SLH Course	C/SLH Media	C/SLH Print	C/SLH Audio	C/SLH Video	C/SLH TV	C/SLH CD-ROM	C/SLH VCS	C/SLH (Internet)
CS 1	220	$AC = \frac{£660000}{8000} + £90 = £173$	3 000	4 889	300 – 1 500	1 000 – 16 000	10 000 - 80 000				
CS 2	448	$AC = \frac{£2776518}{8000} + £172 = £519$	6 198	7 979 – 9 074			38 000	121 882	5 054 – 20 414		
CS 3	560	$AC = \frac{£76529}{1500} + £122 = £173$	137	870	165		20 835				
CS 4	700	$AC = \frac{£105003}{638} + £109 = £274$	150	1 024	856		3 159				
CS 5	456	$AC = \frac{£48640}{1500} + £85 = £119$	107	304	304						
CS 6		$AC = \frac{£17000}{1260} + £293 = £306$			189						
CS 7	75	$AC = \frac{£9675}{75} + £134 = £263$	48		139					476	179
CS 8	600	$AC = \frac{£76800}{500} + £75 = £229$	128	244	220	1 746				158	
CS 10	80										163
CS 11	380	$AC = \frac{£120600}{375} + £178 = £500$			495						

Note: a: That numbers were not rounded does not mean that they should not be taken with a grain of salt. We abstain from rounding only to allow to link the numbers more easily to the numbers in the case studies. B: Case study 9 is not listed because of the different cost structure of videoconferencing and the different approach chosen.

Bibliography

Before citing the references on which our argument is based, some general comments serve as a guide to the literature.

One body of literature examines the definition of open and distance learning, a term, which two traditions brings together. Reference to openness reflects the political agenda of much distance education, with its intention to broaden participation in further and higher education in order to include social groups, which have been hitherto underrepresented (Young in Paine, 1988). Besides looking at widely accepted definitions of distance education, like those of Keegan (ed. 1993) or, more succinctly, Perraton (1991), it is interesting to look at programmatic formulae such as Peters' definition of distance education as the 'most industrialised form of education' (Peters in Keegan, 1994).We can infer an interest in scale economies from this definition.

Of direct relevance for our research was the literature on the cost-effectiveness of dedicated open and distance learning institutions. The British Open University was evaluated in its early stages by Wagner (1972 and 1977) and Laidlaw and Layard (1974). These early evaluations found it more cost-effective than conventional institutions. Two distinct performance indicators have been developed to assess the cost-effectiveness of open and distance learning institutions, recurrent cost per student and cost per graduate. Ansari 1992 did similar research within India. The relevant literature has found that while the cost per student for open and distance learning tends to compare favourably with that of conventional education, the cost per graduate is less convincing (Perraton 1982, AAOU 1993 and Dhanarajan *et al*. eds. 1994).

There exists a further body of case studies on the economics of educational media commissioned by the World Bank and undertaken by UNESCO (UNESCO 1980, 1982). The case studies use a common methodology which facilitates the comparison of results. The methodology is presented in Jamison (1972, 1977) and Jamison, Klees and Wells (1978). A succinct exposition of the methodology is found in Orivel (1987). Many of these case studies were done in developing countries, and assess distance teaching in a more general political framework. The articles of Carnoy and Levin (1975) and Klees (in Carnoy 1995) also take this approach. More recently Potashnik and Adkins (1996) have published some case studies on information technology projects in developing countries for the World Bank. The same authors reviewed (also in 1996) the research papers of the World Bank on education and technology in a second World Bank paper.

The more narrow literature on costing of distance education is limited. Perraton (1982b) and Rumble (1997) are among the most important summaries of the field. A practical guide to costing was edited in 1990 by Crabb. There are references to cost-effectiveness in Hunt and Clark (1997), Beaton (1995) and Curran (1996).

The development of information and communication technologies is important for issues of cost-effectiveness in open and distance learning for various reasons. The new technologies have a different cost structure from conventional distance education and may make open-learning strategies attractive for on-campus teaching also. Rumble (1992 and 1994) has discussed the implications of this for dual-mode institutions.

To get an idea of the scope of the new technologies a certain understanding of their nature and some of their technical characteristics is relevant. An introduction, which puts the Internet and the new communication media into a historical perspective, is Winston (1998). Angelides *et al.(*1997) give an overview on multimedia information systems and Cunningham *et al*. (1996) provide a good introduction into CD-ROM based publishing. A good introductory summary of the educational applications of many of these technologies can be found in Collis (1996).

A substantial amount of information is available on the Internet itself. We made use of various websites, which provide technical information and even product advice (the Ukerna website on videoconferencing systems is one example). Case study reports and evaluations can also be found on the Internet. Relevant to our case was the Annenberg/CBB project report (1997). Less detailed but quite illustrative was the documentation on 'Benefits and Costs of Learning Technology' by Doughty et al. (1997). Also conference documentation, like IDRISS'98 in Bristol, is increasingly in full detail made available on the net. (We include the relevant websites in a separate section of the bibliography.)

Some economic implications of the new technologies are examined in Egan 1996 (on multimedia) or, with specific reference to the Internet, in MacKnight and Bailey (1997). But they refer more to the general problems of regulatory frameworks and pricing options than to the costs of educational media.

Publications, which look at the cost implications of educational technologies in some detail, are rare. Rumble (in Mason and Kaye, (1989) published a cost assessment of the Cosy experience at the Open University. Phelps et al. (1991) looked at costs of computer mediated communication. An important inroad in the problem of costs of educational technologies was made by Bates study on technology in open learning (1995).

There is a long tradition of research into the comparative effectiveness of different educational media. As distance education has to rely on media to bridge the distance to the learner, it is necessary to examine whether you can teach as effectively through media as in the conventional classroom. A substantial body of research has been carried out over many years which consistently shows that there are no significant differences between the educational effectiveness of different media (Chu and Schramm, 1968, Russell, 1997). Perraton (1987) summarised this line of argument as media equivalence theory. It was radicalised by Clark in the claim that media do under no circumstance affect learning (1983). This was criticised in a widely quoted article of Kozma (1991), which claimed that media may well influence learning. The debate is succinctly summarised by Carter (1996).

Kozma's article reflects a tradition, of arguing that, notwithstanding their similar effectiveness, there were practical advantages to be found in matching a particular medium to a particular educational task. Laurillard (1993) gives a synoptic summary, which links media capabilities to different aspects of teaching.

A number of writers look at how media function in different contexts including traditional classroom teaching and explore the capabilities of media there. Snyder (1998) investigates the implication of changing from print to screen, Somekh and Davies (eds. 1997) and Maier et al. eds. (1998) both present a series of case studies of the use of information technology in teaching and learning. Specific reference to the use of the Internet is made by Forsyth (1998). Hiltz (1995) gives an enthusiastic endorsement to computer mediated conferencing. In general it can be observed that most case studies have quietly abandoned any comparative intentions and concentrate on exploring the teaching and learning potential of the different media.

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