MODULE 8

The use of technology

Overview

Technology is considered today to be an essential tool in everyday living and its impact is increasingly being felt in the realm of education. While many persons – educators and laymen alike – support technological innovation in the curriculum, technology is often viewed as a panacea for the ills of the system. This is largely because of the dizzying pace at which newer and more sophisticated forms of technology have been appearing, each a little more complex and more difficult to understand. Not being able to comprehend each device completely, many people are nevertheless convinced that technology is 'good' for education.

In this module the technology issue, as it applies to education, will be demystified. Basic information will be provided that is relevant to planners in education and finance about the range and possibilities of existing technologies, their relative costs and benefits and the appropriateness of each for different contexts. Also relevant to the topic of educational financing is the potential of technologies, especially the newer technologies, not only to enhance education but to change it.

Objectives

By the end of this module the participant will be able to:

1. Define technology;
2. Identify the different kinds of technology available to education;
3. Assess the costs and benefits associated with each kind of educational technology;
4. Evaluate the appropriateness of different kinds of educational technologies for different contexts;
5. Recognise the implications of technology in changing traditional notions of education/schooling;
6. Summarise the meanings of the many technical terms associated with 'new' technologies, included in the glossary.

Introduction

Technology can be simply defined as a tool that can be used to improve the level of performance in any activity. In the case of education, that activity is teaching, with the hope that increased learning will take place.

Technology may appear in the form of printed texts, or technical devices such as overhead projectors. The organised and packaged view of the teaching/learning event into objectives, activities and evaluation using measurement instruments, based on theories which conceptualize learning in terms of inputs and outputs is another aspect of technology in education. Distance education is a technological endeavour because of the considerable know-how necessary to produce and deliver programmes. 'New' technologies refer to computers linked to networks of information.

Planners in Ministries of Education and Finance will need to centre their deliberations on the introduction of technologies into education in terms of improving levels of equity, efficiency and quality in the system. In the context of their situation, they will have to decide which technologies are associated with most benefits relative to costs. On the whole, technology is an expensive innovation so that they must also consider the possibility of partnerships, in paying for desired levels of technology in education. If non-traditional players are being brought into the field of education, then their roles and that of the Ministries of Education and Finance need to be made explicit.

Equity

Technologies which can enable vast audiences to participate in education, i.e. distance education modes, are often promoted for those countries where universal primary and secondary education have not yet been achieved. However, such technologies have been more evident at the tertiary level to date. They are especially relevant to people hitherto excluded from traditional face-to-face interaction in classrooms, such as those living in isolated areas; those who are disabled in some way; busy, working people; or those who have dropped out of education and would like to continue at their own pace. The potential of distance education technology goes a long way in satisfying the criterion of equity.

Efficiency

One objective of national governments is to prepare citizens for the world of work through education. Globally, the face of work is changing rapidly and

to satisfy the needs of citizens the education system should provide them with the means not only to become technologically literate, but also with the competencies necessary for working in a technology-based environment. This largely refers to the 'new' technologies and satisfies as well the needs of governments because having many citizens technologically educated makes the country well poised to take advantage of opportunities to share in movements towards globalisation and become competitive. If such investments in education pay off in terms of national development, then the system will be considered efficient.

However, the situation differs from country to country. It may be that in some countries planners will have to confine their attention to the provision of basic education, perhaps through distance technologies. Making a sizeable thrust into 'new' technologies in education may not be possible at this time. If the investments in education pay off in terms of providing universal primary education and high graduation rates, then this education system can be considered to be efficient.

Quality

The development of educational technology is often a collaborative effort between the private sector and education experts. The latter include specialists in writing, editing, subject areas, evaluation, graphics and design, curriculum and educational psychology. Considerable financial outlay is necessary to develop programmes and tools sensitive to learner needs. As a result the technologies help to produce materials of a high standard capable of ensuring learners achieve positive outcomes. This attribute of educational technology can increase the levels of quality in the system.

Once decision makers deliberate on the benefits of equity, efficiency and quality accruing from technological innovation, they then need to consider the cost structures of each kind of technology to assess their cost-benefit ratios. Contextual factors may then help to indicate what technology is appropriate for that particular country.

Who pays?

Since educational institutions provide the largest market for educational technologies, governments are increasingly entering into partnerships with the corporate sector to intensify the presence of technology in the formal teaching/learning environment. In this way they will be better able to provide for the learning needs of their citizens, and at the same time forge profitable links for business and industry with education while addressing the national development goals of the country.

Increasingly as well, governments are moving away from bearing much of the costs of higher education and allowing those who benefit from education – parents and students – to pay a larger share of what it costs to educate them. Planners need also to bear in mind that the great flexibility of learning brought about by distance and 'new' technologies enables a lot of people to become learners outside of the traditional system. They will pay most of the costs of their own education. It is not a far cry from this to see primary and secondary education being transmitted by non-traditional means, in the long run lifting much of the financial burden from the state.

The expense of technology and its pivotal importance to life today is forcing planners in education and finance to forge links and collaborative structures with many different kinds of organisations that can better facilitate the increased presence of technology in education. This incursion of other groups and interests into education is something that is relatively new to traditional systems. It demands that Ministries of Education and Finance devise a technology plan for education – consisting of broad policy guidelines indicating their preferences for the kinds of technologies to be adopted and their vision of technology in the system as the twenty-first century unfolds. Such a plan will make decision makers focus on what they actually want technology to accomplish and move them to more consistent positions, appropriate for the particular country.

Issues in the financing of education technologies

What is the range of technologies available to education?

(i) Classroom-based

The earliest forms of technology in education – the blackboard, chalk and the printed text – are still with us. For most classrooms, especially in countries of the developing world, they continue to be the primary tools of transmission. In North America, Europe and Australia, audio-visual aids have also become commonplace. They include radio and television broadcasts, video presentations, transparencies and overhead projectors, and slides.

These technologies are used by the classroom teacher to better facilitate delivery of educational programmes. They provide interesting stimuli for learners who tend to be more motivated when a variety of resources are used. Learning styles differ and, as a result, better outcomes are ensured by teaching through multi-media technology. Over the last few decades, however, schools from the primary through to the tertiary level in industrialised countries have witnessed the large-scale installation of

computers in classrooms. They are typically used as tools in drill and practice, in spelling and arithmetic, in solving equations, in developing graphic skills and to become familiar and adept with 'new' technologies, i.e. accessing the many paths to knowledge open to students who become technologically literate. However, computer use in schools tends to remain orchestrated and controlled by the classroom teacher.

In classrooms throughout Asia, Africa, Latin America and small island states, the provision and use of audio-visual aids are uneven or non-existent. The richer countries and better-endowed schools may have some or all of these technologies, including computers. However, the main concern in developing countries tends to be not the dearth of technology in classrooms, but the dearth of schools. Involvement of technology in education in many parts of the developing world may focus more on accessing previously unreachable populations than on upgrading the quality of transmission in traditional classrooms.

(ii) Educating at a distance

Distance education refers to a mode of delivering a course of study in which the majority of communication between teachers and students occurs non-contiguously, and the two-way communication between teachers and students necessary for the education process is technologically mediated. (Maxwell, 1995, p. 43)

The earliest form of distance education is more than a century old – the familiar correspondence course – transmitted largely through print materials. Today there is a vast array of different media and combinations of media used in the delivery of distance education – a checklist is given in Box 1. The case of the University of the West Indies is highlighted in Box 2, where distance education is based on the old correspondence course idea of print materials, but with tutorials and video-conferencing built-in. Box 3 describes Mexico's successful venture into providing educational television courses combined with print materials and community-based teachers at the secondary level .

While reading and reflecting on the materials in Boxes 1, 2 and 3, consider the following questions:

- How familiar, as a planner in education or finance, are you with the array of technologies listed in Box 1?
- To what extent do you consider that a sound understanding of these technologies enables you to do your job better?

- Is there a reliance on information from product developers for technological innovation in the education system?
- What is the context of planning in your ministry – is there a clear-cut policy on technology in education?
- Select a technological innovation in education in the recent past in your country. Consider the rationale for choosing the specific mode – were the arguments based primarily on equity, efficiency or quality factors? Who paid and who benefitted?

Box 1

List of Distance Delivery Systems

Systems	*Media*	*Delivery mode*
Print	Print materials – programmed instruction guided lessons.	Mail
Audio	Audio cassette	Mail
	Radio broadcast	Radio transmission
	Audio teleconferencing	Operator-assisted
Electronic graphics	Electronic board	Telephone lines
	Fax	Telephone lines
Video	Instructional Television Fixed Service (ITFS)	Microwave
	Interactive TV; Video Conferencing	Microwave; Cable; T-1 Line; T-3 Line; Fibre Optics; Satellite
	Video Tape	Mail
	Videodisc	Mail
Computer	Computer-assisted instruction	Mail
	E-mail Conferencing	Telephone line; T-1 Line; T-3 Line; Fibre optics
	Internet; WWW; Digital video conferencing	Telephone Lines; T-1 Line; T-3 Line; Fibre optics

Source: Chen, 1997, p.35

Some of the terms used above refer to complex and specialised forms of technology. As an aid to understanding, a glossary has been compiled and is to be found at the end of the module. It will also include other specialist terms used in the module to help the reader clarify his or her understanding of the topic.

Activity 1

As an initial exercise before studying how to cost different forms of technology:

- *Suggest which of the technologies listed above might be cheapest when implementing distance education;*
- *Describe the factors that would cause a country to choose other modes, besides the cheapest, in implementing distance education programmes.*

Box 2

Print-driven Distance Education Courses

The University of the West Indies has begun the process of becoming a dual mode institution, i.e. courses will be offered both face-to-face on the various campuses as well as by distance. Campuses are located in Barbados (Cave Hill), Trinidad (St. Augustine) and Jamaica (Mona). The thrust in distance education is mainly aimed at learners in the non-campus territories, although many other types of learners will find the distance mode convenient.

Courses are to be conveyed largely by print materials specially produced by course development teams. The print materials consist of a Study Guide which contains the course content and assignments and a Course Reader consisting of the assigned readings for the course. Each student has the opportunity to meet with the Resident Tutor in his/her home territory for tutorial purposes. Each semester, the Course Tutor from one of the campuses, will give three two-hour teletutorials. These can be both audio and video conferencing and are primarily for raising questions and issues rather than for delivery of content.

In 1995 a needs assessment was conducted to establish the level and types of need for distance education within the English-speaking Caribbean. The study revealed a strong demand for tertiary level courses in all territories, particularly at the certificate and degree level. While

most reactions were cautious because the participants were unaccustomed to the distance mode in learning, they said that they would settle for it if some face-to-face contact could be included. Learning at a distance was readily appreciated for the convenience it afforded them in remaining employed while participating in tertiary level courses.

Source: Adapted from UWI, 1996

Activity 2

1. *Suggest reasons why the 'old' correspondence course idea is now considered inadequate for the transmission of distance education.*
2. *What do you think are the challenges of developing print-based materials for distance education courses?*
3. *The main thrust of distance education technologies in the West Indies has been at the tertiary level. Consider why that is so, especially when universal secondary education has not yet been achieved.*
4. *How will the philosophy of educational technologies directed at the secondary school learner differ from that developed for learners at the tertiary level?*

Box 3

Providing Secondary Education through Television – Telescundaria, Mexico

One of the most successful and sustained distance education efforts in the world is Mexico's well-known Telescundaria programme, initiated in 1968. Telescundaria is now an important component of Mexico's educational system, providing access to quality secondary education to 690,000 students throughout rural Mexico through a combination of television programming, books, and community-based teachers. It grows at a rate of almost 20 per cent annually.

Mexico's satellite capability has made possible ready access to students living in rural communities of less than 2,500, where access to conventional secondary education is particularly limited. Telescundaria today serves students in almost 12,000 schools.

In a landmark of international collaboration, Mexico's Ministry of Education, its domestic satellite authority and several Central American nations agreed in 1996 to use Mexico's Solidaridad Satellite for international utilisation of Telescundaria. Costa Rica is the first to implement such plans. Mexico is making available an invaluable store of 3,600 fifteen-minute television programmes and associated texts and teacher guides, which are being supplemented by Costa Rican programming.

Telescundaria is remarkable in its full institutionalisation within Mexico's Ministry of Education, its continued commitment to both growth and quality and the smooth co-ordination between community teaching resources and nationally produced educational programming. Its new regional approach marks a breakthrough. By overcoming traditional resistance to the use of educational materials developed elsewhere and by combining those with local programming, the economies of scale inherent in educational broadcasting can be realised more fully.

Source: Adapted from Block, 1998, pp. 149–150

Activity 3

1. *Refer to Box 1. Is the Telescundaria programme more likely to be ITFS or interactive TV?*
2. *What are the hallmarks of excellent television programmes produced for distance education?*
3. *Suggest what may be the thinking behind the adoption of radio and television in Latin America as its main distance education modes, rather than print-based materials or computer networking technologies.*
4. *Consider the view that distance education technologies try to duplicate the classroom environment of a good teacher.*
5. *Consider also that such technologies occur on a continuum from the 'old' correspondence idea of little interaction to present multi-media systems designed to foster and simulate such interaction.*
6. *Consider the proposition that all distance education modes examined up to now are an attempt to duplicate the classroom-based environment where there is a good teacher.*
7. *Summarise the advantages and disadvantages of distance-based education and classroom-based education.*

However, there are distance-education delivery systems, based on 'new' technologies, which differ in fundamental ways from traditional classroom-based teaching. Such technologies are derived from computers networked to interface with other devices and information systems that are generally called Information Technology. Box 5 describes some aspects of this latest addition to the store of distance delivery systems and Box 6 looks specifically at a major component of information based technologies – the internet.

Box 4

Enter Information Technology

Compact discs and CD-Roms, micro-computer-based laboratories, the Internet, virtual reality, local and wide area networks, instructional software, Macs, PCs, laptops, notebooks, voice mail, e-mail, satellite communication – the list of 'hot' technologies available for education goes on and on. Can these technologies help the education strategist face the challenge of an education for all in an age of globalisation?

'Information technology is the fundamental underpinning of the science of structural re-engineering. It is the force that revolutionises business, streamlines government and enables instant communications and the exchange of information among people and institutions around the world. But information technology has not made even its barest appearance in most public schools. Before we can get the education revolution rolling, we need to recognise that our public schools are low-tech institutions in a high-tech society. The same changes that have brought cataclysmic change to every face of business can improve the way we teach students and teachers. And it can also improve the efficiency and effectiveness of how we run our schools'.
(Gerstner, Jr., (1995), speech to the US National Governors' Association)

Role of Information Technology

1. Improvement of learning and instructions
Technology can be very powerful as an instructional tool for basic skills. It is infinitely patient with drill-and-practice. It can store and retrieve immense databanks of facts, sample problems, exercises and other curriculum resources. These are the areas in which the information management technologies are most valuable – storing, processing and retrieving information.

Technology can also be powerful in driving new approaches to learning that involve more student interaction, more connections among schools,

more collaboration among teachers and students, more involvement of teachers as facilitators and more emphasis on the skills of information seeking and assessment, exploration of open questions, problem-solving, critical thinking, design and construction of new knowledge and understandings. A key understanding is that these new approaches are quite different, with different objectives.

2. Improvement of policy planning, design and data management
Education policy development is an intricate process that requires reliable and timely data that are policy-oriented and user-friendly. Here information can be valuable in storing and analysing data on education indicators, student assessment, physical and human educational infrastructure, cost and finance. The technology can help not only in diagnosis but, more importantly, it can assist in constructing scenarios around different intended policy options to determine requirements and consequences. Each scenario can then be systematically analysed and evaluated, not only in terms of its educational desirability but also in terms of financial affordability, feasibility and sustainability over a sufficient period of time to show results.

3. Support of educational personnel
Technology allows teachers to overcome the isolation they experience in their schools and provides them with continuous professional development. Connected to an information infrastructure, teachers can communicate with other teachers and professionals and can access data banks, libraries and other vast stores of information. As technology in the school allows teachers to perform traditional tasks with a speed and quality that were unattainable before, it will permit better use of their time not only to teach differently but also to develop professionally.

4. Improvement of school management
The same elements of computing and telecommunications equipment and service that made businesses more efficient and cost-effective can be applied to schools and school systems to enable principals and superintendents to streamline operations, monitor performance and improve utilisation of physical and human resources. Technology also has the potential to support the management of complex, standards-related instructional processes in ways that have previously been achieved by only the most advanced schools and skilled teachers. It can also promote communication among schools, parents, central decision makers and businesses, fostering greater accountability, public support and connectivity with the marketplace.

Source: Adapted from Haddad, 1998, pp. 23–27

The view expressed above is that Information Technology is the inevitable tool for organising and facilitating all aspects of life in the twenty-first century. Its advantages for education not only encompass new and flexible ways of learning at a distance, but also seem invaluable to policy makers in ministries, as well as to teachers and principals in their different pursuits. Given all these uses, what role can policy makers give to Information Technology when they are devising educational strategies for small states?

Box 5

How are Networks Used for Education?

The concept of 'Internet' refers to a vast network of interconnected computer networks that enables computers of all platforms to share services and communicate directly. The Internet refers to the public network, while intranets are *private* networks, with gateways to the Internet accessible only by members of that organisation. The Internet is a progeny of the first computer network in the world, the ARPANET, which was inspired by the need to share resources, to facilitate human communication and interaction, and to augment human intellect through distributed collaboration. This vision is being fulfilled by educational applications of networking.

The ARPANET began in 1969, and electronic mail over distributed networks was invented in 1971. Educational applications of computer networks followed almost immediately. By the mid-1970s, academics began to use computer networks to augment educational activities in their university classrooms and network learning began.

An overview of on-line education and training indicates that the Internet and intranets can be employed in one of 3 modes: adjunct mode, mixed mode and totally on-line mode. In *adjunct mode*, networks are used to enhance regular classrooms and distance education. The major applications involve enriching classroom activities by using networks for class discussions; extending office hours for Q&A; assignment submissions; enabling class collaboration and team projects; enhancing group knowledge, work, and analysis; and expanding access to communities of learners, practitioners, experts, and research resources. Networked classroom approaches (linking classes in different disciplines and/or countries), TeleApprenticeship, Ask an Expert and Electronic Field Trips are examples of adjunct mode applications. In *mixed mode*, a significant portion of the educational activity occurs on-line, while the remainder occurs in traditional mode of face-to-face classrooms or

distance education. The applications include professional development programmes, continuing education, training, credit courses, and labs. In *totally on-line mode*, all education or training activity is conducted on-line. Examples include on-line courses special interest courses,and just-in-time training.

Source: Adapted from Harasim, 1998, pp. 184–85

Summary

This section of the module has explored the range of technologies available to education – both classroom-based and at a distance. The next section will deal in detail with costs.

The issues raised in this section concerned:

- the potential of technology to raise the levels of equity, efficiency and quality in the education system;
- the need for decision makers to become more knowledgeable about the various options in educational technology and to have at least a general understanding of the specialist terms associated with 'new technologies';
- factors relevant to the choice of appropriate technology for a country or region, for example contextual considerations such as whether basic literacy has already been established or whether print or television is a better medium given the intended audience;
- an understanding of the bulk of distance education technologies as striving to duplicate the learning environment of classrooms – the more effective distance education programmes involved a mix of media more likely to simulate face-to-face interaction;
- the potential of 'new' technologies
  - to transform education by providing learners with a means of becoming independent of formal, directed structures (either classrooms or conventional distance education media)
  - to be applicable not only to learners but also to teachers, principals and policy makers as a training and information management tool
  - in facilitating the transition of developing countries towards values and practices more clearly aligned to the global information economy

– as a problem within the context of small, developing states;

- the increasing involvement of partners (business and industry as well as loan agencies) in the provision of educational technology, resulting in a reduction of costs to the government;
- the need to establish a technology plan for education at the policy level.

This section has explored the range of technologies available to education – both classroom-based and distance-based. The next section will deal in detail with costs.

The costing of educational technologies

Why cost?

The array of educational technologies has the power to beguile. Notwithstanding this apparent allure, planners must engage in a rigorous cost analysis of the proposed intervention. This is imperative not only because of scarce resources, but because citizens entrust their monies to public officials to be spent wisely and responsibly. For example, there must be caution in imitating the experience of developed countries where the costs of technology are lower and so the cost per pupil, in terms of average per capita income, is less of a burden to the population than it is in developing countries.

Lessons abound as well in the many technological innovations that have turned out to be white elephants. Take the case of Trinidad and Tobago. In the 1970s and 1980s large revenues were earned in the petroleum sector. Human capital theory urged educational investment in citizens as being the primary resource in fostering national development. This thinking drove a massive school building programme, of junior secondary schools and senior comprehensives, complete with an extensive array of curriculum choices from academic and pre-technician to industrial arts. The emphasis was on provision and access, rather than quality and efficiency. Today, these schools continue to be plagued by an image problem – spectacular and chronic failure – and an obsolete technical-vocational specialist curriculum for which much of the equipment lies unused or has broken down. The huge recurrent costs could not be sustained once oil prices fell.

Most of the recent technologies have been produced in the developed world. As third world peoples, we need to be able to separate the hype of the product developers from the utilitarian things we want to know about the product and what it takes to have the product work optimally. Cost is a

major factor – 'upfront costs', 'hidden' costs, 'running' costs, unit costs. Engaging in a cost analysis will clearly demonstrate the likely options.

The unit cost that is most often used in analysing the economics of technological innovation, particularly of distance technologies, is the average cost per student. This is more relevant for our purposes than other unit costs, such as the average total cost per graduate or the average cost per teacher, because what makes good economic sense in supplying distance education is the volume of students it serves.

Not only about costs

Costs by themselves are not a useful tool for analysis, even cost per student. Costs must be kept in perspective, i.e. they must be related to the goals of the education system. To be of value they must be aligned to pedagogical criteria conducive to improving the outcomes of the system. In other words, if costs differ substantially between two modes of technology, planners do not necessarily have to opt for the cheaper medium, but must also consider the capability of each in achieving a range of higher order learning skills. Hence, planners in both Ministries of Education and Finance need to have some in-depth understanding of the pedagogical potential of competing technologies as well as of their relative costs.

Technology and traditional schooling

A critical view of the whole question of technology in the curriculum, especially in small states where the resources may be particularly difficult to come by, is that they cannot afford *not* to get involved. The traditional way of 'doing' schooling demands a heavy reliance on labour intensive technologies, considered to be much too expensive to be sustained even in the short term.

Teachers in such environments remain central to learning, and small countries continue to have to pay out huge sums as recurrent expenditure in salaries and benefits. When they speak of improving the system, it is envisaged largely in terms of reducing teacher-pupil ratios, training teachers and upgrading their salaries and conditions of work – all expensive options. If this vision of education remains unchanged, such states will find themselves in a spiral of escalating costs without much improvement in quality. Investing in educational technologies, particularly distance technology, based on rigorous cost analysis, becomes a realistic and inevitable economic decision.

Fixed and variable costs

Fixed costs refer to the investments that must be made initially to make an innovation a reality. In the case of educational technology, this could be the purchase and/or building of the necessary infrastructure. Where computers are being introduced, the fixed costs refer to the purchase of hardware, the writing of software packages, the installation of peripherals, namely printers and scanners, as well as the wiring and surge protectors that may be necessary to safeguard a reliable electricity supply. It also refers to the costs inherent in developing radio and television programmes, and the writing of books or other print materials. If the technology is to make a significant impact on the system, often training has to be instituted and a central mangement capacity maintained. For example, if a country decides that schools must be equipped with televisions and video recorders, personnel have to be trained to maintain and operate this equipment and a central organising body has to be put in place to co-ordinate the management of this operation.

Fixed costs, then, refer generally to the heavy initial investments made to put the form of educational technology in place in the first instance. It is considered 'fixed' because its component costs are not expected to escalate if its users increase. For example, investments in educational television often incur high fixed costs in terms of establishing a broadcast capacity, in user costs of satellites, and payments to producers and those developing the actual programmes. If 10 students or 5000 students are added to the audience, it would hardly affect the fixed costs.

Variable costs are those costs that tend to vary with additional users. In producing distance-education print materials, the fixed costs are those of the course development team, namely writers, editors, graphic artists and word processing personnel. The variable costs are those incurred in distributing materials to additional students and will vary from year to year. If more students enrol, more materials will have to be printed; if face-to-face tutorials are part of the programme, more will have to be scheduled, incurring costs for teacher time; if teletutorials are structured into the transmission of the course and more students come on stream, more centres will have to be built, as may be the case in outlying islands.

Costs can be precisely worked out (Box 6) and compared with each kind of technology, for example classroom-based as opposed to distance technologies (Box 7). It is also possible to compare the fixed and variable costs for each kind of distance technology (Box 8).

Box 6

The Basic Cost Function

The total costs of an enterprise are made up of both fixed and variable costs. Fixed costs do not vary continuously in relation to changes in volume of activities, although they may change if activities are ended or if there are very significant changes in volumes. Variable costs tend to increase or decrease directly with fluctuations in the volume of activity.

The basic cost function for any educational system is:

$$T = S^1/_2 + C\ddot{a} + P^1 + F$$

where

T = total cost

S = the number of students

C = the courses which are being developed

P = the number of courses being presented to students

F = the fixed cost of the system (includes administrative costs and overheads)

$^1/_2$ = the direct cost per student

ä = the direct cost of developing a course

^{1} = the direct course-related cost of presenting a course

The total direct cost of teaching students is $S^1/_2$, the total direct cost of courses in development is Cä, and the total direct cost of courses in presentation is P^1. The variables for which volumes of activity are identified here as being of significance are S, C and P.

Source: Adapted from Rumble, 1988, p. 91

Activity 4

- *In distance education courses, enumerate at least four examples of student-related costs?*
- *Suggest at least four examples of the direct course-related costs of presenting a course.*
- *Which of the factors listed in Box 6 affect variable costs?*

Box 7

Costs and Classroom-based Technologies

Blackboards and chalk

What are their essential characteristics? They are cheap, readily available, portable, require nothing from the surrounding environment to function, need almost no maintenance, and can be mastered by anyone who possesses basic literacy. And they are effective in helping children learn at all educational levels – primary, secondary, and post-secondary. That's pretty good. These are the qualities we might expect the ideal educational technology to have. Blackboards and chalk in fact constitute a kind of benchmark. They help us see what questions to ask when assessing educational technologies. And it seems fair to ask how many of those new technologies possess all – or even a few – of the qualities possessed by blackboards and chalk.

Source: Adapted from Puryear, 1998, p. 42

Teachers

In conventional teaching, the time of teachers remains the most important element of the costs. In most cases, it accounts for more than half of total costs. In contrast, the fixed costs tend to be modest: the use of the building and equipment and the relatively rudimentary preparation of teaching materials. Under those conditions, there are no significant returns to scale. As long as there are enough students to fill one class, it matters little whether they number a dozen or a million.

Source: Adapted from Castro, 1998, p. 32

Box 7 suggests that not only is chalk and blackboard cheap and versatile, but it is also effective in teaching at all levels.

Activity 5

1. *Do you think students and teachers would agree? When decisions about technology in the classroom are to be made, how much of an input do those at the chalkface have? Are decisions based only on costs and benefits as compiled by supervisors and experts?*
2. *Consider that for conventional classrooms with minimal technologies to deliver quality education, there must be a highly trained, qualified and motivated teaching force – expensive to achieve and maintain (large variable costs). Is this a viable proposition for classrooms in the third world?*

3. *Technologies cater to different learning styles and intelligences and the materials are usually of a high quality. They are also expensive – high fixed costs. Is it feasible to increase the presence of technology in classrooms in the third world?*
4. *Discuss whether conventional classroom teaching continues to be viable in the third world.*

Box 8

Costs and Distance Technologies

With technology-intensive teaching, the fixed costs predominate and the variable costs are much lower. First of all, the machines must be purchased. Computers cost at least three thousand dollars if peripherals, rewiring and other technical costs are included. TV sets and VCRs and parabolic antennas cost less than that, but still are far more expensive than any other piece of equipment used in traditional classrooms. When we consider the infrastructure necessary for broadcast transmissions of TV signals, the numbers are not at all modest. Satellite reception requires additional equipment that remains expensive despite price drops. By the same token, software for computers and teaching materials for TV programmes are very expensive when they are good.

Variable costs, however, tend to be quite modest with technology-intensive teaching. The main component is instructors or other forms of labour. The variable costs relate to the conventional end of new instructions – namely, the teachers and aides who use them.

The implications of this distribution of costs could not be clearer. The use of new technologies is associated with powerful economies of scale. As noted, under conventional teacher-intensive technologies per capita costs tend to remain the same or almost the same whether there are one hundred or one million students. In contrast, with new technologies, cost depends on how many share the fixed costs of preparation and installation of equipment. A T.V. programme such as Telecurso 2,000,* which cost close to $50 million to develop, will have a cost per student of $5,000 if 1,000 students attend and $10 if 5 million students attend. The latter figure is not an unreasonable prediction for this programme during its lifetime. Educational software which typically may cost $300,000 to produce is usually sold at $20 or $30, due to the huge scale of sales.

Therefore, it is the expected scale of utilisation which should determine the mode of instruction. With few students, one hires a teacher; with thousands of students, technology-intensive alternatives may be less expensive. It is assumed that for every hour of classroom contact, a teacher has to invest another hour of preparation. For every hour of class, it takes five hours to prepare written materials. But every hour of instruction using an interactive CD Rom requires at least 300 hours of preparation. Hence, in order to justify the use of more complex instructional technologies, it is necessary to have a much broader clientele.

Source: Adapted from Castro, 1998, pp. 32–33

*Telecurso 2000 is a distance education programme transmitted via TV and video cassettes in Brazil. It offers a basic curriculum to millions of young adult workers, plagued by illiteracy and incomplete schooling. Learning can be individual or as a group in a tele-classroom with an instructor or as informal mentoring in a learning facility equipped with TVs and VCRs. (Falcão, 1998)

Checklist of costs for educational technologies

1. School- or classroom-based:

Technology	Fixed costs	Variable costs	Recurrent costs
Audio	Purchase of radios/tape recorders, cassettes; production of radio programmes; electrical capacity/batteries	Almost nil. If student numbers rise, more radios can be purchased relatively cheaply	Electricity/batteries; audio cassettes
Visual	(i) Purchase of slide and/or film strip projectors; films/slides; screens; an electrical capacity (ii) Purchase of overhead projectors; transparencies; markers; screens; electrical capacity	Almost nil. Only one of each kind of projector in an A-V room may satisfy demand – on a rotating class basis An additional OHP wheeled to classes may be desirable	Expanding stock of films/slides; transparencies; markers; electricity; equipment maintenance
Audio-visual	Purchase of TV sets, VCRs and video cassettes; production of the programmes; an electrical capacity	Almost nil. One TV and VCR in an A-V room will satisfy demand, on a rotating basis, even if numbers increase	Expanding stock of videocassettes; electricity; equipment maintenance

Technology	Fixed costs	Variable costs	Recurrent costs
Computers			
(i) CAI – computer aided instruction	(i) Purchase of hardware – monitors, CPUs, diskettes, scanners, printers; and, software – sometimes multiple copies of the same programme. Paper. Ink cartridges. An electrical capacity, surge protectors. A maintenance contract	More students mean more CPUs, monitors, diskettes, paper, ink, software Two-thirds students to one computer is workable, but a 1:1 ratio is desirable	Upgrades of software and/or memory capacity. Printing cartridges. Paper. Electricity. Renewal of equipment maintenance contracts
(ii) Multi-media application	(ii) All the above costs plus hardware – CD-ROMs and a multi-media kit i.e. speakers, headphones, multi-media software, CDs	Additional multi-media kits. Networking capability and client-server configurations	All the above
(iii) Computers and Internet access	(iii) All the above plus the installation of several telephone lines, server access charges and modems	It is impractical for a whole class to be on the Internet at the same time, hence only 2–4 telephone lines may be installed	All the above plus monthly server access and telephone charges

2. Distance technologies:

Technology	Fixed costs	Variable costs	Recurrent costs
Print materials			
(i) Correspondence courses	Payments to experts for course development; Printing and distributing costs; a central management body. Possibly the cheapest option – must print large volumes to be cost-effective	Costs of printing and distributing; wage bill of tutors and examiners will rise if numbers rise	Updates of courses (possibly once every 5/6 years); printing, distribution costs; paper; wage bill; warehousing
(ii) Print material with audio video cassettes	Costs as above plus: an electrical capacity; the production of audio and video programmes; the purchase of cassettes to give or lend to students More costly than (i) but more interesting materials	Costs as above – reproducing and distributing the materials and payments to tutors will rise if numbers rise	Costs as above. Electricity. If students borrow cassettes there will be administrative costs in tracking and storing the items; if they are given to, or bought by, students there are replacement costs

Technology	Fixed costs	Variable costs	Recurrent costs
(iii) Print material with face-to-face and tele-tutorials (audio/ video conferencing)	As in (i) above – course development; printing and distribution; and administrative costs plus an electrical capacity; establishing buildings/ learning centres; purchase and installation of transmission equipment; developing a satellite or terrestrial broadcasting capacity; a telephone bridge to connect many sites; conveners – high quality speakerphones; and maintenance contracts [Expensive – high fixed costs but high quality interaction between students and tutors is possible]	If student numbers rise there will be increased costs for: reproduction and distribution of materials and payments to tutors. Also increased building capacity may be needed Expensive – high variable costs because as student numbers grow so too do the numbers of tutors or the numbers of hours they have to work. Tutor time is expensive	Updates; stock, printing and distribution, wage bill; maintenance of buildings and equipment; telephone line and electricity charges
Radio			
Interactive radio broadcasts	Course development costs – both the radio programme and print materials used in conjunction with the broadcasts. A radio broadcast capacity or purchase of airtime [Radio airtime is relatively cheap. Print materials are to be used during and after the daily broadcasts. Radios are regarded as being ubiquitious – not a cost to the educational authority. A low-cost medium to reach large populations at distance]	Almost nil. This medium tends to be used widely in schools and thus tutor salaries/ buildings/infrastructure are already accounted for. If numbers increase, costs will be printing and distribution of materials. If used for adult learners and remote students, free community centres and local volunteers as tutors can be used	Updates. Electricity charges/batteries. Costs will depend on whether airtime is purchased from a commercial provider or whether the educational authority sets up its own broadcast capacity. If the former, then costs will be mainly airtime. If the latter – maintenance of transmission and studio equipment and the salary bill of broadcast workers

Technology	Fixed costs	Variable costs	Recurrent costs
Television Interactive television broadcasts	Course development costs for the TV programmes and accompanying print materials Costs for printing and distributing materials. Purchase of TV sets for those who have to use a learning centre. An electrical capacity. Purchase of airtime or costs in establishing satellite links and transmission of programmes. Maintenance contracts	Almost nil. As above Although television airtime is expensive, programmes can be beamed at non-peak hours. An education TV channel could be established. For adult learners, courses can be taped via VCRs and played back later	Updates. Printing and distribution of materials. Electricity. Maintenance of buildings and equipment. Satellite/cable or airtime transmission charges. Salary bill for tutors in the field and ancillary workers
Tele-communications Computers (i) Internet and the World Wide Web	Website construction, on-line course development costs. Hardware : computers and peripherals (for example modems) and telephone lines. Server access charges. Buildings/study centres	If users increase more telephone lines will have to be installed	Monthly electricity, server access and telephone charges. Maintenance of buildings and equipment
(ii) E- mail conferencing	Computer infrastructure, modems, telephone lines, server access, buildings	As above	As above
Audio Conferencing	Telephone system from point to multi-point. Increased line capacity, telephone bridge system and conveners. Buildings/ study centres. Infrastructure	Almost nil tutor costs. One telephone line can transmit to many learners at one site	Long distance telephone charges. Wage bill. Electricity. Maintenance of buildings and equipment
Video Conferencing (i) satellite	Video production facilities; an uplink to a transponder; satellite dish to receive signals from transponder (the downlink). Buildings/ study centres. Infrastructure	Tutor costs. Building capacity. Usually is one-way video and two-way audio via telephone because of the expense of transponder time	Wage bill. Electricity. Telephone charges. Transponder time US$ 200–800/hr). Maintenance of buildings and equipment

Technology	Fixed costs	Variable costs	Recurrent costs
(ii) cable	Cable company charges for airtime. Video production facilities. Certain times are cheap. Students could video-tape sessions and replay later	Almost nil tutor costs. Feed-back via telephone costs. Feed-back via telephone, e-mail, usually not to the cost of the educational institution	Transmission costs, wage bill, maintenance of buildings and equipment
(iii) compressed video i.e. two-way audio and visual communication	Video production facilities. Digital technology – T1 or ISDN telephone lines. A codec to transmit and receive compressed signals. An Inverse Mux to allow greater bandwith. Buildings/ study centres	Tutor costs. Building capacity. Very expensive – can supplement other forms of distance education, e.g. to provide feedback	Telephone line charges. Other transmission costs. Maintenance of buildings and equipment. Wage bill

Summary

The first section of this module explored the range of technologies available to education. The latter part of the module was devoted to the costs involved in technological innovation in the curriculum. The main issues raised are summarised below:

- the structure of costs for any intervention, namely, fixed, variable and recurrent costs;
- traditional teaching as having minimal fixed costs and high variable costs whereas technology intensive curricula incurred high fixed costs but very low variable costs;
- the cost-effectiveness potential of technological innovation for large populations not yet having achieved universal primary and secondary education, and for tertiary learners who find it inconvenient to be full-time students;
- not only costs are important, but the pedagogical value of the technology. Planners have to ask themselves if the introduction of any technology will significantly improve learning outcomes;
- the learning outcomes appropriate for the context will influence the choice of technology:
  - distance education technologies via the mass media seem to have had phenomenal success in Latin America where the desired outcomes

relate to basic literacy and numeracy and citizenship skills;

- tertiary education innovations using distance technologies seem to be successful using print materials as a base where the desired learning outcomes depend on an already literate population;
- the infusion of more interaction between student and tutor, reminiscent of a traditional classroom:
  - learners, even in this highly technological age, still learn best in social situations, for example coming together at a learning centre from time to time to interact with the tutor and other students, or, simulation of such experiences;
  - the 'mix' of technologies promotes interaction. For example, print materials could be delivered with interactive audio and video-conferencing or cassettes; or television and radio broadcasts could be supplemented with print materials;
- the cost factor of developing highly interactive courses:
  - such courses cater to the needs of distant learners and incur high variable costs in terms of tutor time;
  - the less interactive the materials the cheaper they are to produce but the less interesting they are to the learner – and hence of less pedagogical value;
  - older, literate learners may be successful with print-based materials and minimum interaction with the tutor, while younger learners and adults who have not completed their education, may be more motivated using audio and video technologies and accessing tutor help at a study centre;
- the issue of change, namely that traditional teacher costs are high and so, in a context of scarce resources, there is the likelihood of increased investment in distance technologies, but this will ultimately transform the face of education as it has been known:
  - there may be a reluctance on the part of planners to factor in to their technology plans innovations that will be at odds with traditional perceptions of the institution of education;
  - there is the danger that education by distance, offered as an alternative to face-to-face teaching, will be perceived as inferior and that the innovation may flounder on this perception;

- this situation may be less evident in large developing countries where the problem of access has in the past denied education to many;
- it may be more likely in small states where education has been accessible in the past but where today variable and recurrent costs are found to be increasingly prohibitive;

- the extraordinary potential of 'new' technologies to change the way children learn and at the same time prepare them to function in a technology-based society;
- the dilemma posed to developing countries with an obvious and urgent need to become more technologically literate, but plagued by large numbers of functionally illiterate citizens;
- the compromise may be to invest in distance technologies to upgrade the capability of all citizens in basic education before there is widespread access to information technologies;
- however, planners must be aware that in such countries a small, modern, urban sector will develop proficiency in the use of information technologies, creating inequities in the modernisation thrust.

Wrap-up and extended reflection

The flawed logic of educational technology

When we examine the gap between the promises of technology in education and the reality, what we find is a lot of wishful thinking. Advocates of educational technology are almost always optimistic rationalists – people who believe that technology use is the logical way to produce better instruction.

Alas, the world is not rational and logical choices often fare poorly. For example, technology ought to be a good way to reduce inequities between the haves and have-nots. By introducing technology to poor areas (for example, inner cities, developing countries), it should give people in those areas access to the same knowledge and skills as the well-off. This is a logical premise and one that has been put into practice many times. But it almost never works well, because poor areas lack the support or infrastructure necessary to take advantage of the technology or any outcomes that might derive from it. In such a situation, there are probably many more basic aspects (such as a better overall learning environment or more relevant curricula) which would have greater value and impact. Indeed,

in many cases, the reasons for poor learning are not instructional and amenable to improvement via technology. Instead, they are socio-cultural, economic, political, or psychological in nature (definitely not rational). We persist in trying to address these problems through the use of technology because it is the logical thing to do. Technology may have a role to play (for example, teleconferences to share ideas, databases to provide information, desktop publishing, etc.), but it is probably not the real solution.

The field and practice of educational technology has been far too insular in nature, and not well connected or integrated with the other factors that affect education. It has focused almost exclusively on instructional variables to the exclusion of all the other organisational, social, political, and personal considerations at play in a given educational setting. We need to apply technology in a much broader context, as part of a solution or strategy that addresses these other dimensions. We need to stop thinking about learning in strictly rational terms, but as a socio-cultural phenomenon subject to various outside influences. Until we can do so, we should probably use technology as little as possible – in fact, the less the better.

Kearsley, 1998, p. 50

Glossary

Audio teleconferencing	Two-way audio communication in real time between one point to possibly, multi-points, using telephone lines
Broadcast radio/television	One-way audio/video communication from one point to multi-points
Codec	Acronym for coder-decoder; a device that changes analogue audio or video signals into digital format
Computer conferencing	Computers networked to communicate text, video and audio data with each other in real time
Digital video conferencing	Two-way audio and video communication in real time between one point to possibly multi-points, using compressed digital signals via digital phone lines
Digital technology	The conversion of analogue data into digital format reduces the bandwidth needed to transmit audio and video data
E-mail conferencing	Two-way asynchronous communication (electronic mail) from one computer to another using the Internet
Interactive radio/television	Communication that is not necessarily two-way or synchronous – radio and T.V. programmes (and print materials as well), produced in a learner centred manner, with the use of supplementary print or cassettes, and with communication between learners and tutors
Internet	An electronic information superhighway of many computer networks capable of communicating with each other
Inverse mux	A device needed in compressed video transmission which can create greater bandwidth for transmission

Microwave	High frequency radio waves, for point-to-point transmission of audio and video signals
Modem	A device enabling a computer to transmit information via a telephone line by converting the computer signals to audio tones; in this way computers communicate with each other
T-1 line	A digital telephone line, from point-to-point, leased by users, and used at full or fractional bandwidth
T-3 line	A digital leased telephone line that is capable of very fast transmission of full screen, motion video data
Telecommunications	The use of telephone lines to transmit audio and video data and to establish communication between computers
Transponders	The device in communications satellites which receives signals from the ground (the uplink) and transmits it back to Earth (the downlink), users pay for transponder time
Videodisc	A disc of pre-recorded video data that is played on a videodisc player connected to a television screen or interfaced with a computer
World wide web	An enormous network of information sites linked via the Internet to computers at any place in the world; documents are coded in hypertext format i.e. key words and phrases in the text can allow the user immediate access to related materials

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