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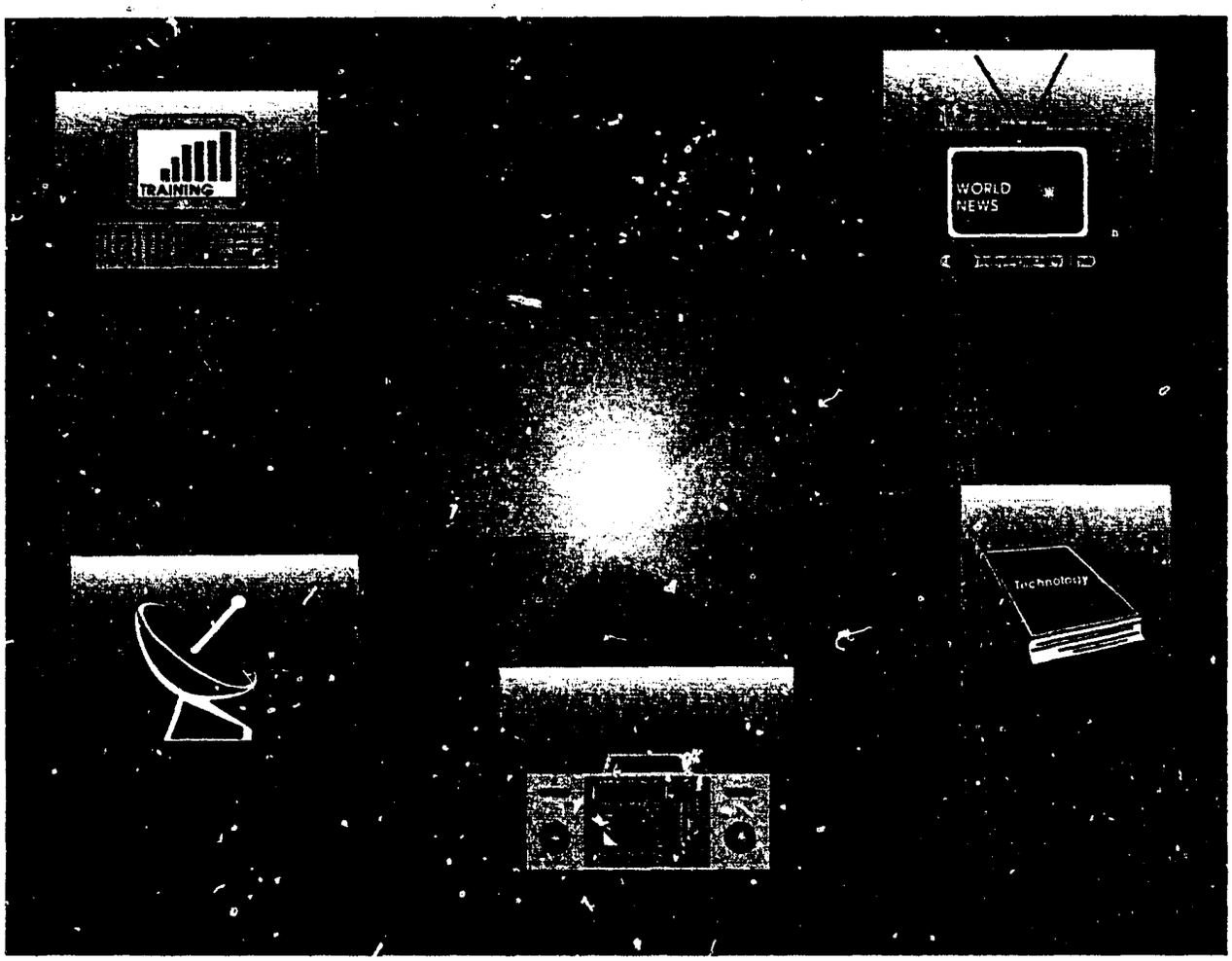
Training Technology Assessment Guide



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Training Technology Assessment Guide

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Preface

AID is in a position to make a significant impact on the development of the "conditions precedent" to real and sustainable economic growth in Africa. The demographics of the continent, however, demand that more than just "more of the same" is done if we are to make progress. We must explore new approaches and means of providing quality training to ever larger numbers of individuals at lower unit costs. This will require a concerted effort and a willingness to try out new ideas.

The current approaches to training in the developing world are inadequate for the current needs. The demographic pressures are tremendous. In most countries more than 55% of the population is under the age of 19. Schools built in the 1960's were designed for an era when the student population was only one third the size it is today. Virtually every provider of training, regardless of the type, is swamped by demand, short of staff, and inadequately equipped.

Other factors exacerbate the strain on training resources. For example, incidence of AIDS (autoimmune deficiency syndrome) infection in many countries disproportionately affects educated populations. One of the devastating effects of AIDS will be the loss of skilled people in countries that desperately need those skills.

Traditional training delivery vehicles simply cannot meet these challenges. For example, using conventional training methods, Cote d'Ivoire can train a mere **40** business students per year. Ghana, only **30** electronic technicians. Zimbabwe, only **15** civil engineers.

To stop the continuing economic decline in the developing world, we must find ways to train **more** people **better, faster,** and at a **lower cost** per person. This will contribute significantly to establishing the conditions necessary for a successful transition to modern, market-led economies.

Over the past decade a variety of new, highly effective training technologies have been developed and tested by the private sector in the United States. These could have a dramatic impact on developing countries. Many have been the direct result of Department of Defense research and the dramatic advances in computer technology and telecommunications. Bringing these to bear on the needs of the developing world can result in the quintessential win-win scenario. There are very good economic, political, and developmental reasons to pursue the application of technology to training in AID-funded projects.

From the perspective of the United States, we can facilitate the conversion of defense-based industry to civilian applications, we can help many small and medium sized businesses gain access to overseas markets, and help to ensure our continued leadership in the training technologies that will be essential to the successful utilization of our own labor force as we enter the era of "Workforce 2000."

From the perspective of the developing world, for the first time in history Africa, for example, can have access to the same quality of technical expertise that is available in New York or Stuttgart or Tokyo. Not only can the expertise be made available, it can also be provided when

and where it is needed, and in whatever language is required to make it understandable. Training and technical expertise can be geared to the needs of the target populations rather than to the availability of an "expert" willing to travel to a given country at a particular time.

From the perspective of AID, there are many advantages to pursuing the use of technology to improve the quality and availability of training. Doing so would permit accessing technical expertise previously unavailable to the Agency. It would also allow AID to train more participants in technical disciplines that are critical to achieving project impact. The cost per trainee could be reduced to a small fraction of what is currently expended, permitting a broader dissemination of the material both geographically and in terms of target audiences. Furthermore, most of the firms active in these new technologies are SBA-certified "small businesses" that would be very responsive to even a modest AID procurement. This would permit AID to expand the field of small businesses that benefit from service delivery contracts with the Agency and thereby broaden its constituency in support of continued funding for Agency activities.

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SECTION I

Introduction

This report was developed to help you determine the best media to use for a particular training project.

To choose a technology for a given training situation, it is necessary to determine the requirements of the training situation, and to weigh the advantages and disadvantages of alternative technologies. For example, computer-based technologies (CBT, IVD, DVI, CD-ROM, CD-I) deliver greater interactivity and often higher results in terms of learning and retention. Yet this improved capability has a price, including higher costs to produce and modify the courseware, as well as to procure and maintain equipment.

To help you assess the merits of alternative technologies, this report includes three tools. Section II provides a quick reference that briefly lists the advantages and disadvantages for each technology. Section III is a Media Matrix you can use to weigh the advantages and disadvantages of alternative media for a particular project. Section IV offers an in-depth look at each technology.

It is important to note that although each technology is presented separately, powerful training impacts can be gained by combining technologies, e.g., using video cassette along with computer-based training, or using print as a portable reference to complement interactive videodisc training.

It is also worth emphasizing that these technologies do not necessarily substitute for classroom training. They can also be used to enhance the effectiveness of an instructor who lacks strength in a particular subject area.

HOW TO USE THIS REPORT

The first step is to consider the key conditions of the particular training situation. These key conditions include:

- *Content.* Examine the content of the material you want to teach. For example, does it have any special requirements such as the need for frequent revision; would motion video and sound be most effective for training?
- *Audience.* Evaluate the audience, e.g., its level of expertise, literacy, etc.
- *Environment.* Consider the conditions of the audience, e.g., are they in a remote area, scattered over a large area, etc.
- *Expense.* Consider required expenses, such as the cost of a trainer, capital cost of technology, etc.
- *Installed base.* Determine the technology already in place. For example, are radios or television sets available? Are there microcomputers already available? In situations where certain technologies already exist, capital costs for adding powerful training capability may be relatively low.

The second step is to use the Media Matrix in Section III. To do so, check the criteria required by your training situation. Refer to the matrix to see which technologies are most appropriate and least costly in meeting those criteria. In addition, use the matrix to assess how you can gain synergies by combining technologies that have different strengths and weaknesses.

The third step is read the in-depth discussions in Section IV to gain further information about particular technologies in which you are interested.

A final note: this document offers guidelines for ten complex technologies; inevitably, there are special cases for each technology that could not be included here.

CHOOSING A TRAINING TECHNOLOGY: HIGHLIGHTS OF LESSONS LEARNED

Despite significant investments in training by USAID and other donor agencies, it is clear that current and future training needs cannot be met with face-to-face training methods. The numbers of trainees are too great, the cost of training trainers, or delivering existing experts to classrooms, is too high.

Yet failing to train skilled individuals in key areas has its own cost. Too few or poorly trained health practitioners, for example, exact high costs both financially and in terms of human suffering. Thus, short-term "savings" in training can ultimately raise other expenses due to lack of skilled personnel. Conversely, the cost of technologies that help train more people better, faster and more efficiently can be considered an investment rather than an expense.

Today there are a wide variety of training technologies from which to choose. Selecting the best technology, or combination of technologies, for a given training situation requires weighing the advantages and disadvantages of the alternatives. This *Training Technology Assessment Guide* aims to support those technology choices by examining ten of the major training technologies. Here, however, we would like to highlight some of the major "lessons learned" about the technologies covered in this guide.

In considering who must be trained:

- When training large numbers of people who have varied skills sets, and when "hands on" experience is important, computer-assisted instruction is highly appropriate — this includes computer-based training (CBT), interactive videodisc (IVD), compact disc-read only memory (CD-ROM), and other laser technologies. In India, for example, IVD is used to train irrigation engineers who vary widely in experience, background, and skills.
- When the objective is to provide large numbers of people with information on general subjects, then broadcast media, such as radio or instructional television, are appropriate. An example is the use of television in some African countries to inform farmers of improved agricultural techniques.

Broadcast media are also effective for general education. An example is Mexico's *Telesecundaria* System, which provides secondary education to students who otherwise would not have access to it.

- When training relatively small numbers of people, audio and video cassettes and print — or a combination of cassettes and print materials — are often most appropriate. For example, a water authority department in Pakistan uses videotape to train technicians in specialized areas.
- When reaching out to young people with socially sensitive information about personal behavior, easy-to-use computer-driven "games" on a kiosk can be extremely powerful. For example, one program in Egypt uses a digital video interactive (DVI) kiosk to disseminate information about drugs and health issues to young people. The easy-to-use kiosks are placed in school lobbies where young people can casually use the machine for "fun," while learning about the dangers of drug use and other health-compromising behavior.
- When trainees are not functionally literate, then educational comic books, broadcast media (radio or TV), video cassettes, or laser technologies can be efficient and effective. The choice of technology depends on *what* is being taught and *how* it must be taught. For example, if visual information is important, then video or laser technologies are more appropriate than radio and comic books.

  If "hands on" training is important, then the preferred choice is either laser technologies or broadcast TV supplemented with face-to-face training. In Indonesia, for example, one firm uses IVD to train factory workers with low literacy skills.

In considering where the trainees are located:

- If trainees are widely dispersed and it is difficult to bring them together for scheduled classes, then laser technologies (e.g, IVD, DVI) or broadcast media are appropriate.

  Laser technologies can be used without a trainer, enabling trainees to go to the training site and use the training program at a time convenient for them.

  Broadcast media can deliver the instruction to a TV or radio that is accessible to the learner. For example, the Nepal Radio Education Teacher Training Project used broadcast radio for in-service training of teachers.

  The choice between the two sets of technology — laser technologies vs. broadcast media — depends on *what* is being taught and *how* it must be taught (see below).
- If trainees are in remote areas, teleconferencing or broadcast radio or video can be effective. However, if complex topics are covered, and/or feedback is important, teleconferencing is more appropriate than broadcast media. One West Indies teleconferencing project served small groups of adults in isolated areas who wanted training in professional areas.

In considering how training is conducted:

- If "hands on" experience is important, and difficult, dangerous, or expensive to provide, then interactive videodisc and digital video interactive provide a highly effective substitute.

If little or no video is necessary to provide the "hands on" experience, then CD-ROM offers a less expensive alternative. An IVD training program in a Malaysia chemicals company, for example, lets trainees practice safe methods where mistakes in the real world are dangerous and expensive.

- If repeated "hands on" experience or periodic reinforcement of behavioral changes are needed, then the laser technologies can be highly appropriate. For example, a Venezuelan petroleum company uses IVD to provide readily available "refresher" training for electricians.

  If repetition or simple reinforcement is required, then video cassettes or print can offer good, low-cost alternatives.

*In considering **when** trainees are trained:*

- If lessons must be available at times convenient for the individual trainee, then the laser technologies can substitute for instructor-led classes. Private firms in several developing countries (e.g., Malasia, Saudi Arabia, Venezuela, Brazil) use IVD so that workers can fit training into their work schedules, rather than having to leave the workplace for classes.

*In considering **why** technology will be used rather than face-to-face training:*

- If there are not enough trainers, or if existing trainers do not have adequate skills, then broadcast video and radio can provide information, and help structure an effective training approach. Alone, however, they are not effective for building skills and changing behavior.

  Teleconferencing can expand the number of trainees who can be reached by a single instructor, and provide interaction. However, it is difficult to provide visual information, to serve very large numbers of trainees, or to provide "hands on" training.

  Laser technologies, particularly IVD and digital video interactive (DVI), can serve as a substitute when there are not enough qualified trainers, and can provide simulated "hands on" experience that can alter behavior.

*In considering **what** is being taught:*

- For complex material, broadcast television is better than radio. In many cases, computer-based/laser technologies and teleconferencing are even more effective. In Saudi Arabia, for example, one company's intensive, trainer-led instruction for electricians had an attrition rate of 50%. When the company switched to IVD training, the attrition rate dropped to 8%. In part, this change was attributed to the greater ease of learning complex material with the IVD than in the classroom.

- If very high quality instruction is important — beyond that feasible even for available teachers, then broadcast radio, video or the laser technologies are most appropriate. For example, an IVD project in India drew on a number of world experts to develop innovative content for the IVD programs. Another example is a mathematics interactive radio program that drew on a number of experts for its design.

SECTION II

Summary of Advantages and Disadvantages

REFERENCE GUIDE

This section provides a short summary of the advantages and disadvantages of the technologies covered in this assessment. For a more extensive discussion of each technology, see Section IV, "Technology Assessment Guide."

Print

Print materials include a wide range of alternatives, from technical textbooks to educational comic books. Although print materials are not usually considered to be "training technologies," they are included here because they represent a critical medium used to improve training in developing countries.

Advantages

- Flexible
- Provides portable reference
- Simple print materials are inexpensive
- Does not depend on electricity
- Can provide self-paced learning
- Many existing materials available

Disadvantages

- Associated with passive learning
- Does not provide feedback
- Difficult to distribute

Computer-Based Training

"Computer-based training" (CBT) utilizes only a microcomputer. No additional equipment is necessary. This category includes IBM PC compatible equipment (DOS-based) and Macintosh equipment.

Advantages

- Some systems provide video, sound, and graphics in addition to text
- Provides immediate feedback
- Many existing programs available
- Relatively easy to modify
- Offers self-paced learning
- Can link to global networks
- Can be used for tasks other than training

Disadvantages

- Limited capability for video, sound, animation
- Typically text-intensive
- Moderately high capital costs
- Requires computer administrator
- DOS-based and Macintosh are incompatible

Interactive Videodisc

Interactive videodisc (IVD) systems include a microcomputer with a video overlay board, a laserdisc player, and may have special "input devices," such as a touch screen.

Advantages

- Combines video, slides, text, graphics, sound, animation
- Gives immediate feedback
- Software is relatively easy to revise
- Provides simulated "hands on" experience
- Offers self-paced learning
- Many existing programs available
- Can substitute for trainer
- Studies show trainees learn faster and retain more than in conventional classroom
- Can hold vast amounts of material
- Can be used for tasks other than training

Disadvantages

- High capital costs for equipment
- Different systems are usually incompatible
- Requires computer administrator
- Video portions are relatively expensive to revise

CD-I

Compact disc-interactive (CD-I) systems generally come pre-packaged as a single unit. The CD-I system includes a microcomputer, CD-I reader, and a monitor. The system has more limited power than stand-alone microcomputers.

Advantages

- Combines video, slides, text, graphics, sound, animation
- Gives immediate feedback
- Trainer is not required
- Lower cost than IVD, CD-ROM, or DVI systems

Disadvantages

- Limited video capability
- Offers limited instructional capability
- Video portions are relatively expensive to revise
- Few existing programs available

CD-ROM

Compact disc-read only memory (CD-ROM) systems include a microcomputer and a CD-ROM drive. The CD-ROM drive can store huge volumes of information—often as much as an entire encyclopedia.

Advantages

- Combines video, slides, text, graphics, sound, animation
- Gives immediate feedback
- Offers self-paced learning
- Can substitute for trainer
- Many existing programs available
- Can hold vast amounts of material
- Can be used for tasks other than training

Disadvantages

- Limited and crude video
- High capital costs for equipment
- Relatively expensive to revise
- Requires computer administrator
- Standards are not established

Digital Video Interactive

Digital video interactive (DVI) systems include a microcomputer, a special digital video board, and a large hard drive. They may have a special "input device" such as a touch screen.

Advantages

- Combines video, slides, text, graphics, sound, animation
- Gives immediate feedback
- Relatively easy to revise
- Provides simulated "hands on" experience
- Offers self-paced learning and animation
- Can substitute for trainer
- Can be used for tasks other than training

Disadvantages

- Video quality not as good as IVD
- Amount of video is more limited than IVD
- High capital costs for equipment
- Development is often more expensive than IVD
- Requires computer administrator
- Systems are difficult to configure
- Few existing programs available

Educational Television

Educational television (ETV) is defined here as broadcast television specifically designed to be part of a training curriculum. (ETV can also include microwave transmission or closed circuit TV.)

Advantages

- Offers programs from many countries
- Provides clear video (depending on broadcast signal)
- Can reach large numbers of people with standardized material
- Many existing programs available

Disadvantages

- Does not provide immediate feedback
- Generally poor for "hands on" training
- Moderately expensive capital costs for equipment
- Relatively expensive to revise
- Not appropriate for vocational training for narrow audience
- Requires broadcast infrastructure
- Moderately high delivery costs for broadcasting

Teleconferencing

Teleconferencing systems consist of an audio system, which includes a telecommunications link, microphones, and, often, loudspeakers. They might also include a visual component, such as a television or microcomputer.

Advantages

- Provides immediate feedback
- Offers programs from many countries
- Audio-only systems are relatively low cost for training remote groups
- Relatively easy to revise
- Many programs available

Disadvantages

- Difficult to provide visuals
- Generally poor for "hands on" training
- Requires coordination among multiple bureaucratic agencies
- Requires telecommunications infrastructure

Radio

Radio includes broadcast stations and receivers (radios). Interactive radio utilizes programs with pauses for student responses and for program responses.

Advantages

- Interactive radio offers immediate feedback
- Relatively easy to revise
- Reaches wide audiences
- Reaches remote groups at relatively low cost
- Many existing programs available
- Relatively easy to revise
- Can be used with low-skilled facilitator rather than instructor

Disadvantages

- No visuals
- Feedback is highly structured
- Generally poor for "hands on" training
- Not appropriate for training small audiences
- Generally poor for complex instruction
- Requires broadcasting station

Video Cassettes

Video cassette systems include video cassette recorders (VCRs), a television set, and video cassettes.

Advantages

- Offers programs from many countries
- Provides clear video
- Can deliver standardized material to remote or scattered groups
- Many existing programs available
- Appropriate for vocational training for narrow audience
- Can substitute for trainer

Disadvantages

- Does not provide feedback
- Generally poor for "hands on" training
- Moderately expensive to revise
- Relatively expensive to distribute
- Relatively high capital costs

SECTION III

Media Matrix

This section provides insights into the relative strengths and weaknesses of the training technologies covered in this report as they relate to a number of areas of concern to the development training designer. First, the matrix addresses the issues relating to the actual delivery of training content. The practitioner can look at the various categories rated and decide which are critical to his/her training material. A rating of "5" is excellent; a rating of "1" indicates that this is not a good choice. Once the two or three best choices for the delivery of the training material have been determined, one should compare their "costs." The second section of the matrix addresses costs associated with the technologies, such as equipment costs, management requirements, etc. In the "cost" section, a rating of "5" means that the costs are minimal, indicating a "good" situation. Conversely, a rating of "1" has an overall negative implication.

TECHNOLOGIES

CRITERIA 1.Training Needs/Conditions Content-Related	Check the Criteria that apply (✓)	Print	CBT	IVD	CD-I	CD- ROM	DVI	Instr'l TV	Teleconf.	Inter-active Radio	Video
Requires "Learning by doing" that is difficult, dangerous or expensive		1	3	5	4	4	5	2	2	1	2
Content requires revision: - Frequently (once/year or more)		4	4	3	3	3	3	4	4	5	4
- Moderately frequently (once every two years)		5	5	3	3	3	3	4	4	5	4
- Infrequently (less than every two years)		5	5	4	4	4	4	4	4	4	5
Visual information is important: - Slides or photos		4	3	5	5	5	5	3	2	2	4
- Full Screen Video		1	2	5	4	1	4	5	1	1	5
- Partial Screen Video		1	2	5	4	3	4	5	1	1	5
Requires a combination of sound, pictures, video, text, and/or graphic animation		1	4	5	4	3	5	3	1	1	2
Content focus is: - Specialized, for narrow audience		5	5	5	5	5	5	1	3	1	3
- General, for broad audience		5	3	5	5	3	5	5	3	5	5
Type of Skills To Be Fostered											
Hands-on skills		1	4	5	4	4	5	2	1	1	3
Problem-solving and decision-making		2	4	5	4	5	5	2	2	2	2
Recalling facts		3	4	5	5	5	5	3	3	4	3

Appropriateness

1 ——— 5

Poor Fit — Excellent Fit

CRITERIA 1.Training Needs/Conditions continued	Check the Criteria that apply (✓)	Print	CBT	DVD	CD-I	CD-ROM	DVI	Instr'l TV	Teleconf.	Inter-active Radio	Video
Applying procedures to standardized tasks (e.g., administration)		2	3	5	4	5	5	3	3	3	3
Interpersonal skills		2	3	5	4	4	5	3	2	2	3
Characteristics of Target Audience											
Trainees vary greatly in their experience or skills levels		2	5	5	4	5	5	1	2	3	1
Trainees have advanced knowledge and experience		5	5	5	4	5	5	4	4	4	4
Trainees are widely dispersed		3	4	4	4	4	4	3	3	4	2
Number of trainees is: - Small		5	2	1	1	2	1	1	3	1	4
- Large		3	5	5	5	5	5	5	3	5	3
Gathering trainees at one site is difficult or expensive		3	4	4	4	4	4	4	1	5	2
Trainees require repeated and/or ongoing training		5	4	4	4	4	4	2	2	3	3
Trainees are not functionally literate		1	2	5	5	5	5	5	3	5	5
Instructor Resources											
High student/teacher ratios		3	4	5	4	5	5	5	4	4	4
Lack of qualified teachers		3	4	5	4	5	5	3	4	4	4
Difficult to maintain instructional quality		2	4	5	4	5	5	3	3	3	3
No instructor or facilitator available to facilitate		2	3	5	3	4	5	3	2	2	3
Para-professional on site		2	4	5	3	4	5	3	3	4	4

Appropriateness

1 ——— 5

Poor Fit — Excellent Fit

TEC[illegible]ES

CRITERIA 2. Costs of the Technology Financial Requirements	Check the Criteria that apply (✔)	Print	CBT	IVD	CD-I	CD- ROM	DVI	Instr'l TV	Teleconf.	Inter-active Radio	Video
Equipment (overall) Capital		4	2	1	2	2	1	2	2	4	3
Recurrent maintenance and facilities		4	3	3	3	3	3	3	3	4	3
Trainer salaries		1	3	5	3	4	4	2	2	3	2
Equipment managers salaries		5	3	3	3	3	[illegible]	4	3	5	4
Content development costs		1	2	2	1	2	1	1	1	2	2
Delivery costs (assuming equipment already present)		3	3	3	3	3	3	3	2	4	2
Management Requirements of the Technology											
Requires trainer skilled in using the medium		3	4	5	5	5	5	2	2	3	3
Requires high level of management to disseminate new material		1	3	3	3	3	3	4	4	4	2
Requires dedicated management of the technology		5	1	1	2	1	1	3	2	4	3
Technical Requirements											
Requires equipment maintenance		5	2	2	2	2	2	3	2	4	4
Requires good quality - Telecomm network		5	5	5	5	5	5	5	1	5	5
- Broadcasting network		5	5	5	5	5	5	1	2	1	5
Requires careful consideration of future compatibility/extendability		5	3	1	1	1	1	5	4	5	5

Cost

1 ——————— 5

Very expensive — Inexpensive

SECTION IV

Technology Assessment Guide

This section provides a more in-depth discussion of each technology. It is important to note that many training programs are best served by some combination of the technologies presented below. In addition, it is possible to link the technologies themselves, e.g., IVD and print, CBT/CD-ROM.

PRINT

Although print materials are generally not considered to be a training "technology," they are so dominant a part of training in developing countries that they have been included here. Print materials offer a wide range of alternatives from technical textbooks to comic books.

Print

Advantages	Disadvantages
• Flexible • Provides portable reference • Simple print materials are inexpensive • Does not depend on electricity • Can provide self-paced learning • Many existing materials available	• Associated with passive learning • Does not provide feedback • Difficult to distribute

I. Capabilities and Considerations

Content-related. Print materials are extraordinarily flexible, providing options that fit all types of training from sophisticated technical training to conveying simple procedures. Print materials using illustrations and graphics can be effective even for those with low levels of literacy. One World Bank study suggested "The availability of reading material may be the single most ~~consistent correlate of academic achievement...~~" ~~(Farrell and Heyneman).~~

Print can help to provide structure to training lessons and provide material and exercises, portable reference material, and a summary record of each lesson.

Illustrations can be used in print to address needs of low literacy individuals. However, illustrations must be used with care because translation of the message portrayed by pictures

requires experience and a common set of visual references. In general, text is necessary to explain the illustrations.

Often a good source of technical material is equipment vendors. In many cases, they produce manufacturing materials of good quality and distribute them free. Such materials can be complemented by other supplementary materials to support training in the relevant skills.

Print materials also offer a valuable supplement to other forms of media, providing more permanent reference material. Thus, print materials are often used to supplement radio and ETV. Simple print materials can be used as portable references carried away from IVD, DVI, CD-I, and other types of computer-based training.

The disadvantage of using print alone is that it often leads to stereotyped teaching and passive learning. It is distant from the direct experience often needed for training. Another disadvantage that is especially pertinent to training is that print provides no feedback. Even when skilled teachers use print effectively, often the feedback is too late to be helpful.

Development and distribution of print materials is often difficult and time consuming. Books often take three to five years to develop, other print materials two to three years, and even simple print materials one to two years. Distribution of the print materials also takes time. Thus, for content that must be updated frequently, only very simple print materials are appropriate.

Skills development. Print can be effective in supporting skills development. However, using print for vocational training has particular demands. The material needs to be practical and focus on skills development, rather than on abstract discussion.

Appropriate audiences. Print can be developed that will be effective for students with widely different skills and experience. Generally, however, print material must address an audience with a specified, limited range of skills, basic (e.g., literacy) as well as technical. Print generally appears to be most effective as part of the general education system, or relatively structured learning situation.

For adult training, printed text appears to be most appropriate for technical training for audiences accustomed to learning from print, e.g., medical professionals. Illustrated material can be used for other types of students.

There have been mixed reports of the effectiveness of programmed learning, which seem to be most effective for audiences learning basic skills such as literacy and mathematics rather than for technical skills training.

Print can be used by an individual, a small group, or large classes. Because an instructor/teacher is generally required to support the effectiveness of print materials, print is most appropriate for situations in which it is possible to gather at least small groups of students at one site at the same time. Print can also be useful to provide exercises where students require repeated or ongoing practice.

If simple print is developed at low cost, print can be suitable both for small numbers of students and for large numbers. It is often easier to develop small runs of material for relatively small numbers of students, and to distribute to small numbers of groups. Thus, print can be a good alternative where the number of students is very limited over time.

Print can provide material relevant to trainees across a spectrum of skills, from novices to those with advanced knowledge and experience.

Instructor resources. Print materials for technical or professional training must generally be used where an instructor is available in order for the print material to be effective. Where instructor skills are low, special teachers' materials are likely to be necessary, and must be easy to read and use. Because print is far removed from actual experience, the effectiveness of print for training often depends on the availability of skilled instructors.

Text books offer a consistent standard presentation of material that can provide instruction even where trained teachers are not available. In general, however, print is not a good substitute for an instructor. What it does provide are exercises and material that permit instructors to work with large numbers of students, by having some students work independently using print materials while the instructor works with others.

In general, print materials can provide only limited support for improved quality and consistency of training where training capacity varies greatly, making it difficult to maintain standards of desired quality.

II. Requirements

Hardware. Print materials cover a wide range, from textbooks to comic books. The cost of the materials varies equally widely. Often the hardware costs of print lie not in the delivery medium (the print material itself) but in the production equipment. There is also a wide range of that equipment, from printing presses, which are expensive and complex to operate, to desktop computers with laser printers, that are expensive and relatively easy to operate. A desktop publishing system with laser printer can range in price from $3,000 up to very expensive units that cost hundreds of thousands of dollars.

Financial requirements. Textbooks are relatively cost-effective — in studies of education technologies in developing countries, only radio has been shown to be more cost effective across several countries (Lockheed and Hanushek, 1988). One study showed that texts were three to four times as cost-effective as teacher training for low-skilled teachers (Lockheed, Vail, and Fuller 1986).

The cost of print materials varies considerably, depending on whether the materials are developed in the developing country, the kind of print materials, the number of different titles, the number of copies required, the complexity of the materials, and the method of distribution. Simple print materials are generally relatively inexpensive. In contrast, textbook production is relatively complex and costly. In some countries, even simple print materials are too expensive to provide

for all students. In general, however, print materials are highly cost-effective, especially when they can be re-used.

Even when print materials are relatively inexpensive to produce, there are often quite high distribution costs. Delivery costs include the cost of the student to travel to the classroom, and perhaps residing at that site for a few days. Since the student must usually attend a scheduled class in addition to using the print material, the class may conflict with other demands, and travel may be required when travel costs are high.

Management requirements. Despite major donor support, and enormous expenditures (on the order of hundreds of millions of dollars per year), print materials — especially textbooks — tend to be of poor quality and in short supply in most developing countries. The major obstacles are related to management. Most developing countries lack the management infrastructure needed to create good quality materials and to sustain systems for inventorying and disseminating them. Egypt, for example, has a large national textbook program, but continues to have problems producing and distributing print materials that meet students' needs. In other countries, such as Liberia, print based systems for self-instruction often founder due to poor management of production and distribution of print materials.

Often, the demanding management requirements for producing and distributing print materials are poorly understood by those responsible for these activities. They tend to focus on developing curriculum, and ignore the importance of building institutions and human resources that can inventory, supply, and re-supply materials. Furthermore, often the content is inappropriate for the audience.

In order for print to be effective, two major areas of management need careful attention. One is management of the content of the materials. Materials must be tested with the intended audience to ensure that text vocabulary and the illustrations will be properly understood and interpreted by that audience.

The second area requiring management is distribution of print materials. This is a difficult and complex activity and requires considerable commitment of management resources. All too often print materials never reach the intended audience because of distribution problems.

To meet these management needs, trained managers are necessary, with skills in developing an infrastructure that can reliably:

- Develop high quality, relevant educational materials.
- Establish and maintain production schedules.
- Manage inventory and distribution.
- Ensure their proper use in the training environment. (This is a particularly challenging task, as it is difficult to monitor teachers or to maintain a standard training methodology.)
- Revise materials as necessary.

Technical requirements. One of the most attractive features of print materials is the relative ease with which they are used and can be modified. With the exception of textbocks, print materials are relatively easily produced in developing countries, and materials from developed countries can be relatively easily modified to fit the particular setting.

In some cases, printing presses are used — complex equipment that requires trained staff and maintenance services. Increasingly, microcomputers are used, as are laser printers, photographic equipment and other supplementary equipment. These types of equipment also require trained staff, and maintenance services must be available. Small amounts of material are relatively easy to produce using microcomputers and laser printers. Large amounts of materials generally require more sophisticated equipment and more experienced staff. Most developing countries appear to have developed capability at both ends of the spectrum. Some, however, continue to lack the industries required to produce the quantity and quality of materials required in a cost-effective and timely manner; in such cases, printing may have to be done outside the country.

COMPUTER-BASED TRAINING (CBT)

For the purposes of this report, Computer-Based Training (CBT) refers only to microcomputers with no add-on equipment such as CD-ROM, IVD or CD-I players. In the following discussion, both IBM-PC compatible (DOS-based) equipment and Macintosh equipment are examined.

Computer-Based Training

Advantages	Disadvantages
• Some systems provide video, sound, graphics, and animation in addition to text • Provides immediate feedback • Relatively easy to modify • Offers self-paced learning • Can link to global networks • Can be used for tasks other than training • Many existing programs available	• Limited capability for video, sound, animation • Typically text-intensive • Moderately high capital costs • Requires computer administrator • DOS-based and Macintosh are incompatible

PC-Compatible computers. Until recently, PC-compatible CBT offered little more than text on a screen, very limited graphics, and limited, highly structured interactivity. However, with the advent of Windows software and 80486 chips, PC-compatibles can offer access to a large graphics capability, text and sound, and limited animation.

Currently there is also a limited ability to provide very rudimentary video-like images on a 80486 microcomputer. It is also worth noting that major PC-based manufacturers have announced their intention to introduce CD-ROM-like capability into future "basic" PC's.

Macintosh computers. In contrast to the PC-compatibles, Macintosh computers have long offered the capability to produce graphics, sound, animation, and varying qualities of video-like images.

As microcomputers in developing countries are linked to electronic networks through which they can receive information and instruction from anywhere in the world, the courses that can be offered via CBT will greatly expand.

I. Capabilities and Considerations

Content-related. CBT programs are most appropriate for content that is well defined and relatively concrete. CBT is valuable for illustrating concepts and materials, and providing training and practice exercises. The capability and versatility of these programs in their use of graphics, animation, sound, text and limited video will vary depending on whether it is PC-based or a Macintosh, the power of the system, and the type of software.

In addition, it is possible for microcomputers in large cities in many developing countries to link to international electronic networks such as Internet, CompuServe, Fidonet, EUnet/EurOpen, NORDUnet, RARE and Ripe. However, these networks generally operate as a kind of worldwide "E-mail" system or as a complicated-to-use database rather than to provide instructional programs themselves. Thus, they are currently most appropriate for supplementing instructor-led or CBT courses.

CBT content is relatively easily revised, as compared with IVD, DVI, CD-ROM or CD-I. CBT has long been a relatively popular method of training, and is increasingly so as courseware design and expanded systems capabilities permit more sophisticated graphics and video-like images.

PC-Compatible computers. Historically, PC-based systems offered very limited training capability. Programs tended to be text-intensive, repetitive and unimaginative, valuable primarily as a method to provide practice in repetitive tasks more effectively and with more individualized and immediate feedback than was possible with conventional training.

Today, high-end PC-based microcomputers (80486 and higher) can provide graphics, text, sound, limited graphics, and, for some systems, very limited video-like images, along with the interactive capabilities of the microcomputer. Where this combination of media is appropriate, the power of CBT programs has expanded greatly. Some experimental CBT programs use such tools as artificial intelligence to provide innovative training through simulation modeling and other techniques.

However, despite this increased technological capability many CBT training programs continue to emphasize drill and repetition, using visuals only to sustain the student's interest rather than convey important material. Often it is up to the instructor to develop creative ways to use CBT to enhance instruction.

Macintosh computers. Mid-level Macintosh systems also provide text, sound, good graphics, and animation and rudimentary video. However, Macintosh QuickTime software (which comes with all Macintoshes), continues to improve the video quality possible on a mid-range Mac ($1,700 - $3,000); high level Macs can provide moderate quality video. Nonetheless, the Mac does not produce the video or still image quality of IVD or DVI.

CBT programs, if carefully designed, can be complex and sophisticated enough to provide training for students with advanced knowledge and experience. However, CBT is not as effective as IVD, DVI, or CD-ROM for many training applications, particularly training that requires

simulated hands-on experience. (Of course, if the training is for operating a computer system itself, CBT can offer excellent "hands on" training.)

Skills development. Given the high-cost and low-efficiency of vocational schools in developing countries, CBT can offer new options for improving instructional quality.

Software such as the "Electronic Workbench" make it cheaper and more feasible to give students simulated hands-on experience with technical equipment and procedures. At the same time, CBT can be used to improve the basic skills (reading, mathematics, etc.) of students in vocational programs.

Appropriate audiences. As with most computer-based systems, CBT is effective in situations where students vary widely in their skills and experience. CBT programs can be designed to provide self-paced learning and to respond to individual student's comprehension of the material. CBT programs can also incorporate measurement of a student's competency to ensure that learning goals are being achieved.

Although less expensive than IVD, CD-ROM, or DVI, CBT is sufficiently expensive to limit its value to situations having large numbers of students to be trained over time.

Instructor resources. Highly-sophisticated CBT programs may not require an instructor on site. But many CBT programs appear to be most effective as auxiliary programs that enhance and reinforce "classroom" training.

Given the wide range of available CBT programs — and their enormous variation in quality — the most crucial skill an instructor can develop is the ability to identify high-quality CBT courseware.

II. Requirements

Hardware. A CBT system consists of a microcomputer and, for some systems, special internal boards such as audio or video boards. Both PC-base and Macintosh-based systems require a modem to link to international electronic networks.

Financial requirements. The relatively low price of microcomputers today, and the multiple uses to which they can be put, has led to a proliferation of systems in developing countries. Today, the majority of those systems are PC-compatible; however, Macintosh systems are increasingly being adopted due to their greater ease-of-use and versatility.

- *PC-Compatible computers*

  PC-based systems typically range from a low-end of about $900 (offering limited graphics, very limited sound, no video-like images) to a high-end of about $5,000 (providing good graphics, sound, animation, crude video and high level of capability for complex programs).

- *Macintosh computers*

  Macintosh computers run from $900 for the low-end (limited graphics, sound, and animation capability) to over $8,000 for the high-end. Mid-range Macintoshes (approximately $1,700-$3,000) can provide good graphics, sound, animation, and crude video.

Both PC-based and Macintosh-based systems require a modem (approximately $100-$300) to link to international electronic networks.

CBT courseware is generally considerably less expensive to develop than IVD, DVI, CD-ROM, or CD-I programs. The skill sets involved are often available in developing countries to a greater or lesser extent, providing the capability of producing CBT courses at lower cost and higher relevance.

Replication of CBT courseware is very inexpensive — generally the cost of a floppy disk ($.80-$1.30).

Delivery costs of CBT programs are moderate, primarily involving the cost of the student to travel to, and possibly spend a short time at, the site of the computer system.

CBT is usually most effective as part of a larger training program; thus, the student must often travel to the CBT system site when a regular course is being conducted. CBT is also valuable as a "refresher" which can be used at the student's convenience. With the proliferation of microcomputers in developing countries, it is increasingly likely that a student will have a microcomputer available at or near his/her place of work, and will not have to travel far to use the CBT program.

If the training course involves linkages to an electronic network, costs can rise considerably. Even if the network access charge is free, there are charges for time on the network — often more than charges for the same access time in the U.S.

In addition, the telecommunications lines are of dubious quality in most developing countries. As a result, line linkages break down making it difficult to download large amounts of material. It is even more difficult to transmit material within the developing countries than between developed countries and developing country major cities. There are also often high charges for accessing particular programs or databases on the network.

Even the relatively low cost of basic CBT programs, the capital cost for equipment and, more importantly, the development costs of training programs are likely to require large numbers of students in order to make CBT cost effective.

Management requirements. CBT programs generally operate as an enhancement to rather than as a substitute for regular training. Like other computer-based technologies, they also require a responsible person to manage the use of the technology and to resolve problems that arise. Generally these responsibilities are part of the role of the systems administrator who manages microcomputers for the organization.

Management of dissemination of new CBT material is relatively easy, but does require someone with sufficient computer skills to copy software from a floppy disc to the system itself.

Modifying CBT software ranges in difficulty, depending on its complexity; if the computer source code is available, many developing countries have sufficient programming talent to develop and revise CBT courseware produced elsewhere.

As is the case for other computer-based training technologies, the most difficult management challenge is to help instructors integrate CBT programs into the regular training program. This is particularly important for CBT, as it is generally most effective as an enhancement to regular training, rather than as a stand-alone course.

Technical requirements. The primary technical issue of concern with CBT is which system to adopt: the PC-compatible system or the Macintosh system.

PC-compatible systems are currently far more prevalent in developing countries, but an increasing number of developing country organizations are choosing Macintosh systems because they are easier to use. It is worth noting that there are networks available that can link the two types of systems. But like all networks, they can be difficult to manage and maintain in good operating order.

Investment in microcomputers is widespread and growing in developing countries. Unlike industrialized countries, which have greater access to IVD, DVI and CD-I technologies, developing countries are more likely to turn to CBT. Furthermore, it appears likely that "standard" microcomputers will soon include a CD-ROM drive, and the microcomputer processing chips will continue to grow in power and capacity. Thus, CBT courseware will provide growing value at a relatively low cost, and can often be produced in the developing country itself.

INTERACTIVE VIDEODISC (IVD)

Interactive Videodisc (IVD) is a powerful training technology that allows the student to determine the flow and pacing of the program. In most cases, the IVD elements (motion video, slides, graphics, text, and audio) are under computer control.

Interactive Videodisc

Advantages	Disadvantages
• Combines video, slides, text, graphics, sound, animation • Gives immediate feedback • Software is relatively easy to revise • Provides simulated "hands on" experience • Offers self-paced learning • Many existing programs available • Can substitute for trainer • Studies show trainees learn faster and retain more than in conventional classroom • Can hold vast amounts of material • Can be used for tasks other than training	• High capital costs for equipment • Different systems are usually incompatible • Requires computer administrator • Video portions are relatively expensive to revise

IVD programs are categorized into three levels of interactivity:

Level 1: The videodisc program plays images in a pre-set sequence. Level 1 videodisc players offer very limited capability. They cannot process new information, combine video with computer text, graphics, or animation. Student interaction with a Level 1 program is usually through the videodisc player's numeric keypad.

Level 2: The videodisc program has limited interactive capability based on the use of the player's built-in microprocessor.

Level 3: The videodisc player is linked with an external microcomputer, providing complex programs and a high degree of interactivity. The student can interact with the program using

keyboards, touch screen, mouse, or other means. Level 3 programs dominate multimedia industry projects today.

Note: All references to interactive videodisc (IVD) in this discussion refer to Level 3 videodisc programs. References to videodisc in general refer to all three levels of programs.

I. Capabilities and Considerations

Content-related. IVD draws its power from the combination of media it presents (motion video, slides, graphics, animation, text, and audio) and the interactivity provided by the microcomputer. IVD programs offer instant access to a vast visual databases, including high-quality still and motion video segments. Each side of a videodisc can contain 30 minutes of video and sound on each side (the newest generation of discs/players offer 60 minutes/side). This combination of media can provide simulated "hands-on" experiences that engage and stimulate the student to use knowledge and decision-making skills to solve problems and achieve objectives.

Evaluation results from a variety of environments in the U.S. consistently show that students using IVD have greater achievement rates, learn more quickly, and have longer retention rates than those studying with conventional training methods (for example, see Fletcher; Bosco; Kinton). Although there have not been formal studies of IVD in developing countries, reports from private firms suggest similar benefits from IVD. For example, a petroleum company in Saudi Arabia reports that using IVD to train electricians reduced attrition rates from 50 percent with classroom training to about 8 percent with IVD.

IVD is particularly appropriate for training situations in which hands-on experience is important, but would ordinarily be difficult, dangerous, or expensive to provide. For example, IVD is used in medical training, to place medical students in life-like situations where they must make rapid, accurate decisions, without endangering the lives of real patients. In India, IVD has been used to give irrigation engineers field experience that would otherwise be difficult and expensive to provide. In Malaysia, private firms have used IVD to train workers in safe handling of dangerous substances.

IVD is best suited to content that is well defined and relatively concrete, where the learning experience is enhanced by providing realistic, simulated experiences. Thus, although IVD is well suited for training broad audiences on topics of general interest (e.g., training parents, paramedics, and others on oral rehydration), the content should be concrete rather than abstract. IVD has also been shown to be an effective tool for training instructors, by modeling effective teaching methods.

It is also best if the audio-visual material in the program — that part of the program that is placed on the videodisc — is not subject to frequent change, because that would necessitate re-shooting the visual material and re-pressing the videodisc.

It is important to note, however, that the IVD program can be revised relatively easily if the material to be changed is part of the computer software rather than resident on the videodisc.

Careful design can help to ensure that material likely to change is placed in the computer rather than on the videodisc.

It is also possible to leverage the investment in creating a particular videodisc by "re-purposing" that videodisc. Re-purposing involves using the visual material from the videodisc and altering the programming, text and graphics on the computer program to create new courseware.

Finally, it is possible to choose from among a large number of videodiscs that already exist for training in various skills areas (more than 2,200 "off-the-shelf" videodisc programs are available). When considering purchasing those videodisc programs, however, it is essential to ensure that the IVD program of choice is compatible with the hardware that has been procured. Another consideration is the appropriateness of the existing IVD program for the particular culture and needs of the developing country.

Skills development. IVD is particularly powerful for a wide range of skills training, from teaching facts, to training students to apply procedures, to developing problem-solving skills. IVD's ability to simulate a wide range of situations makes it an powerful tool for developing skills through hands-on experience.

IVD has even been effectively used to develop interpersonal skills, which are often considered to require face-to-face training. The Wilson Learning videodiscs, for example, assist U.S. managers in understanding and improving their interpersonal skills for more productive communications with other managers and with subordinates.

Another example is the use of IVD for training irrigation engineers in India; one of the IVD programs helps engineers improve their communications skills and their interaction with water users and water user organizations. Experts who have reviewed this videodisc have described it as one of the most exciting innovations in training these types of skills that they have ever seen.

Another valuable role for IVD, given its ability to simulate hands-on experience, is as a tool to assess students' skill levels, either for entry into more advanced courses, or to determine whether they have mastered a given level of skills.

IVD also allows easy measurement of competency, which can help ensure instructors that they are meeting student needs.

One final and very important use of IVD programs is as a certification tool. Through the use of the computer's ability to monitor student performance, it is easy to design a program that certifies that the student has learned a particular body of information or skill set.

Appropriate audiences. IVD is highly effective in situations where students vary widely in their skills and experience, as the system offers self-paced learning and can be designed to respond to the individual student's comprehension of the material. It can also be used to provide "refresher" training for trainees with varied levels of experience.

Because development of IVD courseware is relatively expensive, IVD is best suited to situations having large numbers of students using the system over a period of time.

IVD is generally used by an individual or small group, although there are technologies available to project the IVD image onto a large screen.

IVD can provide complex material in a sophisticated fashion, including simulation, that challenges the student to apply his/her knowledge and experience in difficult, realistically complex situations. As a result, IVD is valuable for training professionals, and for other students who have advanced knowledge and experience.

IVD does not require an instructor to be present. Consequently, a student can use the IVD system whenever it is convenient for him/her. As a result, IVD is highly appropriate for providing decentralized training in situations where it is difficult to gather students at one site at one time, and/or where students require repeated or ongoing training.

IVD training programs have been successfully used in a number of developing countries, including India, Côte d'Ivoire, Egypt, Mexico, Singapore, Malaysia, Brazil, Venezuela, and Saudi Arabia. Most of these applications are used as part of training programs of private firms.

Instructor resources. IVD's ability to simulate real situations makes it unusually effective in substituting for instructors. As a result, it is particularly valuable when qualified instructors are unavailable or there are high student-to-teacher ratios. IVD also helps to provide consistent, high-quality training, in situations where training capacity varies greatly — depending upon the skills of the instructor — making it difficult to maintain quality standards.

IVD is often used in ways that leverage an instructor's time. For example, prior to taking an instructor-led course, students might be required to take a basic IVD course on their own and so that once the instructor-led classes began, all the students would have the same basis of knowledge. This approach allows the instructor to teach rather than remediate.

II. Requirements

Hardware. An IVD system consists of a microcomputer, a video overlay board (installed in the microcomputer), and a videodisc player. Some systems require a special monitor.

The least powerful IBM-PC compatible microcomputer that should be used is a 286; 386 or 486 microcomputers with VGA display are recommended.

The least powerful Macintosh computer that should be used is a Mac Plus.

Interactive videodisc systems generally vary between $2,000 and $5,000 depending on the components. A very high level system, with power for developing complex training programs, costs approximately $3,500. (It is important to note that this includes a microcomputer that can be used for all of the regular functions of a computer as well as for IVD training).

The equipment cost breakdown is:

- Microcomputers range from $800 to $3,000
- Video overlay boards range from $500 to $1,500
- Videodisc players range from $250 to $2,200

These prices reflect steady declines in price and increases in power, trends that are likely to continue.

It is worth noting that there are special systems that provide some capabilities of IVD systems, but at far lower prices. For example, "laser bar code" systems embed bar codes in print material. The user reads the material — or the instructor leads a discussion — and then sweeps a hand-held reader over the bar code to call up video or still images from a laser disc player. The cost of the user's delivery system is approximately $800 and can provide high quality, full screen video, stills, graphics, sound.

Financial requirements. Although costs vary substantially, IVD systems have relatively high capital requirements, which can be a major obstacle where initial capital is limited. It is worth noting, however, that less expensive IVD systems offer most of the features of the more expensive systems, and can serve typical training needs.

The cost of IVD courseware development varies greatly, depending on several factors, including the level of interactivity, the complexity of the subject matter, the type of equipment, and the complexity of the software design. Some of these costs may be reduced by doing some of the development in a developing country.

The cost of pressing a one-sided videodisc is $1800. After pressing, copies of the disc cost $18 each, with the cost decreasing as the number of discs ordered increases.

Delivery costs are moderate, primarily involving the cost of the student traveling to the site of the IVD, and perhaps residing at that site for a few days. Since the student can use the IVD at his/her convenience, trips to the IVD site can be scheduled when they will not conflict with work demands, or when travel costs are low, or can be combined with other work-related travel.

Given its relatively high capital costs, IVD is most likely to be cost-effective when it will be used by very large numbers of students (preferabiy 1,000 or more over a period of about five years) or can substitute for expensive and difficult-to-obtain expert instructors.

IVD can also reduce the cost of loss of productivity for training time, by having students use the IVD when it will not conflict with work. In addition, IVD can reduce the need for expensive trips to field sites.

For example, in Mexico, one company has found that it saved training costs by putting IVD on the factory floor, where it substitutes for a two-week instructor-led course. The IVD makes

training available on a 24-hour basis, workers can "refresh" their skills at any time, and they do not have to take time off the job to go to a scheduled workshop.

In addition, studies of IVD indicate that students often learn more quickly with the IVD than alternative technologies, saving the cost of employee salaries during training time and requiring fewer workstations for a given number of students during a given period of time. For example, in the Mexico case mentioned above, training takes less time because the IVD tests trainees on each set of skills, enables them to skip segments that they already know well, and learn or refresh skills only where needed.

IVD can also save costs in situations where hands-on training is necessary. For example, through simulation, IVD can substitute for equipment for which "downtime" or damage would be expensive, e.g., teaching truck driving under hazardous conditions, teaching welding skills.

Finally, IVD can provide hands-on experience where student mistakes would be very costly or unacceptable, such as in medical practice.

The savings IVD offers in these areas may well outweigh the cost of the IVD.

Evaluations of IVD in the U.S., for example, consistently find a 40% reduction in learning time as compared with traditional classroom/lecture; and a 50% increase in retention over time. Considerable savings have been documented. Two examples include:

- A U.S. Armed Forces IVD repair course cost $1.7 million vs. $120 million that would have required using conventional instruction.
- An insurance company developed a course of $2 million which originally cost $19 million per year to offer in conventional classroom manner. Furthermore, the training was more effective: in the conventional training program, only 25% stayed with the company; in the IVD training 75% stayed in the firm.

Finally, the improved training provided by IVD may reduce other costs. As one official in India stated, "We spend a lot on [irrigation] equipment that is not properly maintained. We could actually save money if we had an IVD that could train people to maintain the equipment."

Management requirements. IVD can "stand alone," which means that it can be set up and used at a site, with no need for the instructor to be present. It does, however, require someone responsible to manage the use of the technology, to ensure students use it properly, and to resolve questions or problems that arise. In many cases, these responsibilities are part of the role of the systems administrator who manages other microcomputers for the organization.

Management of dissemination of new material is relatively easy, but it does require someone with sufficient computer skills to be able to copy software from a floppy disc to the IVD system itself.

The major management challenge is to help instructors use IVD to enhance their regular training programs. IVD programs stimulate students to apply knowledge to realistic situations and to develop independent problem solving.

For instructors accustomed to rote learning, effective use of the new technology may require new attitudes about training. For many instructors, however, IVD offers a model of exciting new alternatives for training. As one instructor exclaimed when he saw an IVD program, "This is how *we* should be training people!"

Technical requirements. One of the most critical technical considerations in adopting IVD is that of present and future compatibility between hardware and software. IVD authoring software has recently made it easier to develop programs than can be used on different systems; however, for much of the software already developed, re-programming is necessary in order for the videodisc programs to run on alternative systems.

It is difficult to predict the future of IVD. It may prove to be an "interim technology" that will eventually be replaced by computer systems that provide full video capability from a digital source, such as DVI or CD-ROM. Currently, however, IVD continues to provide the easiest and most cost-effective alternative where interactivity and motion video are required. Furthermore, the very large and growing installed base of IVD systems ensures a useful life of the technology for the coming decade.

Maintenance of IVD systems is similar to that of ordinary microcomputers. In many countries, computer repair facilities can service all components in the IVD systems except for the videodisc players, which are very rugged and sturdy, and rarely require servicing.

CD-I

Compact Disc-Interactive (CD-I) systems were originally conceived and designed to be self-contained, stand-alone interactive entertainment systems for the home market. As such, they are usually priced much lower than IVD, DVI, or CD-ROM systems, while delivering similar capabilities in graphics, animation, text, sound, still pictures, and limited video.

The low-end CD-I players, however, have less instructional capability than typical IVD, DVI, or CD-ROM programs. And while the high-end, industrial CD-I systems are more powerful, they are also more expensive, costing approximately the same as a mid-range videodisc system (approximately $2,200).

CD-I

Advantages	Disadvantages
• Combines video, slides, text, graphics, sound, animation • Gives immediate feedback • Trainer is not required • Lower cost than IVD, CD-ROM, or DVI systems	• Limited video capability • Offers limited instructional capability • Video portions are relatively expensive to revise • Few existing programs available

I. Capabilities and Considerations

Content-related. The strength of CD-I lies in its ability to provide a program format that can utilize sound, pictures, graphics, and moderate quality video, on a sturdy, easy-to-use system (for one assessment of CD-I see Currier). CD-I offers a low-cost alternative when a microcomputer is not already present and will not be needed later. In situations where a microcomputer is already present, however, the marginal cost of adding CD-ROM or even low-end IVD to the microcomputer is less than or equal to the cost of a CD-I system.

As stated earlier, low-end CD-I was originally designed for home use to provide limited, video game-like capacity, with limited feedback and interaction. CD-I systems have generally been used for kiosk-like public information delivery, as well as for other types of relatively simple training programs. Many of the existing CD-I discs are simply electronic databases.

Industrial CD-I delivery systems provide more power, but are also more expensive. Unlike the low-end systems, the high-end systems can include a floppy disc drive that permits the recording of students responses. This provides greater capacity for more complex training.

CD-I appears to be most appropriate for programs that require a combination of sound, photo images, limited video, text, and graphics, and are relatively simple in content and design. CD-I is less appropriate for training that requires simulated hands-on experience than are IVD or DVI, particularly where video is important to provide life-like experience.

Skills development. CD-I's limited capacity makes it less useful for skills training than IVD, DVI, or CD-ROM programs. Where access to still photo images and graphics enhance skills training, and limited interaction is needed, CD-I can be useful.

Appropriate audiences. The cost of CD-I courseware development is often more than IVD, and requires a broad audience for the content in order to make the systems cost-effective.

Low-end CD-I is currently most appropriate for simple training programs. Thus, CD-I can be effective for providing training to students with low level skills and experience.

CD-I can also be used to provide a helpful resource or "library" of images, text, and graphics for students with advanced knowledge and experience. It does not allow measurement of student competency except to a relatively limited extent in more high-end systems.

Instructor resources. CD-I programs are easy to use and do not require an instructor be present while students are using the system. However, the capability of CD-I limits its ability to substitute for a trainer.

What CD-I can provide is a large database of images, graphics, sound, and text that instructors can use to augment and enrich a training program.

II. Requirements

Hardware. Low-end CD-I players consist of a single unit, with more limited computing power than a typical microcomputer, at a price of about $800.

High-end CD-I systems generally consist of a microcomputer, a CD-I disc reader and a television. These "industrial-level" CD-I systems cost about $2,000 or more, including a television, but provide greater capability.

CD-I development systems, upon which programs are created, are considerably more expensive than CD-I delivery systems. Even low-end CD-I development systems cost at least $15,000.

Financial requirements. CD-I delivery systems demand relatively low levels of capital investment, in comparison with IVD, DVI, or CD-ROM systems. However, the lower cost buys much lower training capability, and the value of the CD-I must be carefully considered in view of the types of training applications required.

It is worth noting that if a microcomputer is already available, or will be needed:

- The marginal cost of adding CD-ROM is less than purchasing a CD-I system

- The marginal cost of adding a mid-range IVD system can be about the same cost as purchasing a high-end CD-I system

CD-I systems are relatively inexpensive to repair, where repair facilities exist.

Although the cost of producing CD-I courseware varies greatly, as a rule it is relatively expensive, somewhat more than the cost of developing an equivalent IVD training program (higher software engineering costs than for IVD, but lower video production costs).

The costs of pressing CD-I discs and replicating them, however, are very low, around $900 for mastering then $2 for each copy, with the unit cost decreasing as the quantity of copies ordered increases.

Delivery costs for CD-I are low, primarily involving the cost for the student to travel to the site of the CD-I, and perhaps residing at that site for a day. A student can use the CD-I at his/her convenience, so that trips to the CD-I site can be scheduled to avoid conflict with work demands, or keep travel costs low.

In addition, some portable CD-I players are becoming available, which make it easier to bring them to different sites. However, the high cost of these players, along with their limited capability, makes them inappropriate for most developing countries.

Management requirements. CD-I systems are very easy to use. In some situations, however, they may require someone responsible to manage the use of the technology. This role can be undertaken by someone who is not a computer system professional.

Management of dissemination of new CD-I material is easy, and simply involves distributing a new CD-I disc. Modification of an existing CD-I program is probably not feasible in developing countries.

There are two ways in which the features of low end CD-I — low cost and limited capability — might provide value for developing countries:

- As a multimedia storage medium instructors can use to illustrate material discussed in the classroom, or to demonstrate material or examples that cannot be covered in the classroom.
- As a delivery system for "public information," or for training that is simple in content.

Instructors are unlikely to perceive CD-I as a direct threat, but may consider it to be an expensive and frivolous novelty.

Technical requirements. There is considerable question about the future of CD-I. Many experts believe CD-I today is too slow a technology to survive as the prices of other, more powerful technologies drop. Others believe that the manufacturer who dominates CD-I technology, Philips, will ensure its long run survival through massive investment in market distribution and by upgrading CD-I capability.

Although CD-I has been used in factory automation and other process control systems for more than six years, it has yet to "break through" to broad adoption. Today, the state of CD-I programming is much like that of the early days of IVD — there are few authoring programs, and software is generally more expensive and difficult to develop than for IVD.

CD-I is compatible with the CD-ROM/XA standard. Assuming that CD-ROM/XA drives become more widely adopted (few are available today) they may stimulate a wider audience for CD-I discs.

CD-I hardware is quite sturdy and is easy for students to run.

CD-ROM

Compact Disc-Read Only Memory (CD-ROM) is a storage medium that, together with a microcomputer, offers rapid access to a very large volume of computer graphics, animation, text, sound, still pictures, and a very limited amount of motion video.

CD-ROM

Advantages	Disadvantages
• Combines video, slides, text, graphics, sound, animation	• Limited and crude video
• Gives immediate feedback	• High capital costs for equipment
• Offers self-paced learning	• Relatively expensive to revise
• Can substitute for trainer	• Requires computer administrator
• Many existing programs available	• Standards are not established
• Can hold vast amounts of material	
• Can be used for tasks other than training	

I. Capabilities and Considerations

Content-related. The ability of a CD-ROM to hold large amounts of graphics, animation, text, and photo still images makes it a powerful technology for training applications that require little or no video. However, despite recent improvements, CD-ROM drives continue to be considerably slower than ordinary microcomputer hard disks and videodisc players. As a result, CD-ROM is more limited than IVD in the types and complexity of applications it can handle effectively. Nonetheless, during the past few years CD-ROM has become as popular as videodiscs for multimedia applications, except for programs that depend heavily upon the use of motion video.

Today, CD-ROM is used primarily to store resource materials, and many adopt the CD-ROM format to augment the storage capacity of their hard drives. Thus, while CD-ROM provides an excellent technology for some types of training, it does have limitations. For example, the systems' relatively slow response time and their ability to provide only still photos or extremely small amounts of motion video can pose serious problems for some types of applications.

Like IVD and DVI, CD-ROM is most appropriate for content that is well defined and relatively concrete, where training is enhanced by providing still visual images, graphics, animation, and sound. Unlike IVD and DVI, CD-ROM lends itself more to effective illustrations of the concepts

and materials, and "exercises" with still photos or graphics, rather than providing simulated hands-on experiences. One effective use of CD-ROM is to provide multiple layers of information in a "hypercard" format — with this approach a user can choose to pursue deeper layers of information about particular terms or issues in which s/he is interested.

CD-ROM materials are revised in the same way other laser disc based technologies (IVD, CD-I) are revised. If the material to be revised is contained on the laser disc, a new disc must be pressed. If the material to be revised is contained in the computer, revisions can simply be made to the software. Like IVDs, CD-ROMs can be re-purposed by altering the computer program so that it uses the material on the CD-ROM disc in a new way.

CD-ROM's low cost has given it wide popularity as a storage medium, leading to development of a number of off-the-shelf CD-ROMs which can be purchased for training.

Skills development. Although CD-ROM offers less hands-on simulation capability than IVD or DVI does, it can still accomplish excellent skills training. However, in cases where motion video is required for simulation purposes, CD-ROM is not likely to provide desired results.

For example, an IVD program on equipment repair might show the actual equipment as it operates, with graphics overlaid on top of the image to indicate problems and approaches to fixing them. In contrast, a CD-ROM program is more likely to show a graphic image of the equipment, and illustrate the movement through animation.

Appropriate audiences. Like IVD and DVI, CD-ROM is highly effective is situations where students vary widely in their skills and experience. A CD-ROM training program can access to vast amounts of information at a pace dictated by the individual student's comprehension of the material.

Although CD-ROM programs are often less expensive to produce than those for IVD or DVI, they are still relatively expensive, and therefore most appropriate when there are large numbers of students to be trained over a period of time.

Instructor resources. Like IVD and DVI, CD-ROM does not require an on-site instructor. Therefore students can use a CD-ROM program whenever it is most convenient for him/her (including after working hours, if necessary).

II. Requirements

Hardware. The relatively low price of CD-ROM drives and the proliferation of CD-ROM discs has led to the growing adoption of CD-ROMs in developing countries.

A CD-ROM system consists of a microcomputer with a built-in or separate CD-ROM drive. CD-ROM drives are either IBM-PC compatible or Macintosh compatible. The two types of CD-ROM drives are not compatible, nor are the CD-ROM discs that play on them.

The least powerful IBM-PC compatible microcomputer that should be used with a CD-ROM drive is a 286, and 386 or 486 microcomputers with VGA display are highly recommended. The faster the computer, the more feasible it is to use complex graphics and animation. For many programs, the CD-ROM system also requires an audio adapter board, and may require a video board.

The equipment cost breakdown is:

- Microcomputers cost approximately $1,000 to $3,500
- CD-ROM drives cost approximately $250 at the low-end to $1,800 for very fast drives
- Audio adapter boards vary in price from about $50 to $1,500, depending on quality
- Video boards vary in price from about $400 to about $1,500

Note that the microcomputer can be used for all regular microcomputer applications in addition to training.

Financial requirements. Basic CD-ROM systems offer a way to provide graphics, text, sound, and photo images, at a relatively low capital investment, especially for organizations that already have IBM-PC compatible microcomputers ($250 - $500 for a CD-ROM drive to be added to a microcomputer). Recurrent costs primarily involve routine maintenance of the equipment.

The cost of developing CD-ROM courseware can vary greatly, depending on the level of interactivity and the complexity of the subject matter, the amount of images, sound, graphics, and animation required, and the overall complexity of the design. But in general, the cost is somewhat less than IVD and DVI production costs.

The cost of pressing a CD-ROM disc is approximately $1,200, while the cost of each copy is $1.45, with the unit cost decreasing slightly as the quantity of copies ordered increases.

As is the case for IVD and DVI, delivery costs of CD-ROM programs are moderate, primarily involving the cost of the student to travel to, and possibly spend a short time at, the site of the CD-ROM system. Since the student can use the CD-ROM program at his/her convenience, trips to the CD-ROM system site can be scheduled when they will be least costly in terms of conflict with work or travel costs.

Although CD-ROM systems are not as expensive as IVD or DVI systems, the costs still require large numbers of students in order to be cost-effective.

Management requirements. CD-ROM programs do not usually require an instructor on site. Like other computer-based technologies, however, CD-ROM systems do require a responsible person to manage the use of the technology and to resolve any problems that might arise. Usually, these responsibilities are part of the role of the systems administrator who manages other microcomputers for the organization.

Management of dissemination of new CD-ROM material is easy, since it usually involves only the distribution of new CD-ROM discs.

The most difficult management challenge is to help instructors integrate CD-ROM programs into the regular training program. Like IVD and DVI, CD-ROM programs can be designed to help students learn to apply knowledge and to develop independent problem solving skills. This may conflict with the approaches used by instructors, who are accustomed to rote learning.

In order for the CD-ROM programs to be integrated effectively into the regular training program, it may be important for instructors to develop new attitudes about training.

Technical requirements. CD-ROM offers a major advantage in providing graphics, animation, text, sound, and photo images for a relatively low price. The major technical concern currently, however, is that standards for CD-ROM are not established. There are currently several different CD-ROM standards vying for supremacy. The two major standards are:

- CD-ROM Yellow Book standard (formally, the ISO9660 standard), and
- CD-ROM/XA standard (XA stands for Extended Architecture).

The Yellow Book standard is the original CD-ROM format. The newer CD-ROM/XA format offers far better text, audio, and video than the Yellow Book; however, the distribution of CD-ROM/XA drives is far more limited than the Yellow Book, and very few programs have been developed in that format. Most experts do expect CD-ROM/XA to become the standard of the future. At the same time, new optical storage mediums are being developed on an almost daily basis, which is likely to prevent final standards from being established for some time. It is important to note that some CD-ROM drives do *not* support multimedia applications that include video.

Although CD-ROM/XA drives can play Yellow Book discs, Yellow Book drives cannot play CD-ROM/XA discs. Therefore, CD-ROM drives commonly purchased today may not be useful in a year or two, if the CD-ROM/XA format prevails. (CD-ROM/XA drives currently cost about $1,000 -$1,800 as opposed to the $250-$500 CD-ROM drives.)

It is worth noting that Tandy Corporation and Microsoft have establish a standard "Multimedia PC," which includes an IBM-PC compatible microcomputer, a CD-ROM drive, an audio board, a speaker, and a video board, but the current version of the Multimedia PC is too limited in terms of memory and motion video capability to be truly useful in the future.

Maintenance for CD-ROM drives should probably consist of replacement of broken drives rather than repair.

DIGITAL VIDEO INTERACTIVE (DVI)

Like IVD, Digital Video Interactive (DVI) is a computer-based technology that offers enhanced training capabilities through the use of motion video, slides, graphics, animation, sound, and text.

Digital Video Interactive

Advantages	Disadvantages
• Combines video, slides, text, graphics, sound, animation • Gives immediate feedback • Relatively easy to revise • Provides simulated "hands on" experience • Offers self-paced learning and animation • Can substitute for trainer • Can be used for tasks other than training	• Video quality not as good as IVD • Amount of video is more limited than IVD • High capital costs for equipment • Development is often more expensive than IVD • Requires computer administrator • Systems are difficult to configure • Few existing programs available

I. Capabilities and Considerations

Content-related. DVI offers many of the capabilities of IVD, including instant access to a large database of visuals, graphics, sound and text. Like IVD, the DVI combination of media can create simulated hands-on experiences that teach students how to apply knowledge and develop decision-making skills.

However, DVI does present certain advantages and disadvantages for training when compared with IVD:

- A major advantage of DVI is the ability to modify the video and slides on DVI at a relatively low cost, making frequent content revision easier and less expensive than it is for IVD.
- A major disadvantage is associated with the relatively recent development of the technology. Unlike IVD, which is more than ten years old, there are no "tried and true" DVI hardware configurations, and it can take considerable time and money to put together a DVI system capable of creating the training program desired.

- Another disadvantage is the lower quality video DVI offers as compared with IVD, making it less appropriate for training applications where high quality, clear motion video is important.
- A third disadvantage is the substantial computer memory it requires for motion video segments. As a result, there is a trade-off between the amount of video and the complexity of the programming possible on a typical DVI system. If there is a considerable amount of video, the programming may have to be limited, thereby limiting the complexity and effectiveness of the design.
- Finally, DVI has slower branching than IVD, making it less appropriate than IVD for some complex training.

In general, U.S. private sector firms seeking a training technology with video elements tend to choose IVD rather than DVI. Their choice appears to be based on two major issues. The first is the more problematic quality of a DVI system, in contrast to the "known" quality of IVD technology, which has clearly established capabilities. The second relates to the small number of general purpose DVI products currently available, in contrast to the large number available for IVD. If DVI becomes more popular, more generic programs will, no doubt, be developed.

Skills development. Like IVD, DVI is a powerful training technology for a wide range of skills training. However, when skills training requires at least moderate amounts (more than a few minutes) of good quality video to provide a hands-on experience, DVI will be less effective than IVD.

Some DVI applications provide "performance support," i.e., provide access to information if a worker has questions while conducting a particular operations process. In Egypt, for example, a DVI program provides support to aircraft maintenance workers.

Appropriate audiences. DVI is highly effective for situations where students vary widely in their skills and experience. DVI programs can be designed to offer self-paced learning and to respond to individual students' comprehension of the material. They also allow easy monitoring of the learning progress, helping to ensure that training objectives are being met.

Since DVI does not require an instructor on site, students can use the DVI system whenever it is convenient for them. As a result, DVI is useful in situations where it is difficult or expensive to bring students together at one site at one time. Because DVI courseware is relatively expensive to develop, it is most appropriate when large numbers of students must be trained over a period of time.

Some DVI programs have been developed in Saudi Arabia and Egypt, primarily taking the form of point-of-information kiosks. One program, for example, provides "youth awareness" information about drugs and health issues. The kiosks rotate through schools, where they are placed in the lobbies so students can access them easily.

Instructor resources. DVI's ability to simulate real situations makes it unusually effective in substituting for instructors. As a result, it is particularly valuable when qualified instructors are

unavailable or there are high student-to-teacher ratios. DVI also helps to provide consistent, high-quality training in situations where training capacity varies greatly, depending upon the skills of the instructor, making it difficult to maintain quality standards.

Like IVD, DVI can also be used in ways that leverage an instructor's time. For example, prior to taking an instructor-led course, students might be required to take a basic DVI course on their own and so that once the actual classes began, all the students would have the same basis of knowledge. This approach allows the instructor to teach rather than remediate.

II. Requirements

Hardware. A DVI system typically includes a 80386 (at least 25 MHz) or 80486 microcomputer, a DVI board (installed in the computer), and a hard drive of at least 200 MB.

The cost of DVI systems generally ranges from approximately $2,600 to $6,500, depending on the cost of the components. A good quality DVI system with the power to produce complex training programs is approximately $3,000. (Note that this cost includes a microcomputer that provides all the regular functions of a microcomputer in addition to training). The equipment breakdown is: DVI boards are approximately $1,200 to $2,500; a microcomputer ranges from $1,400 to $3,500. By summer of 1993, DVI playback boards may be available at $500, reducing the overall cost of DVI systems.

Financial requirements. DVI systems have relatively high capital requirements, which can be a major obstacle where initial capital is limited. Recurrent costs for equipment primarily involve routine maintenance of the equipment.

The cost of developing DVI courseware can vary greatly, depending on the level of interactivity, the complexity of the subject matter, the type of equipment, the amount of video required, and the overall complexity of the design.

As is the case for IVD, delivery costs of DVI programs are moderate, primarily involving the cost of the student to travel to, and possibly spend a short time at, the site of the DVI system. Since the student can use the DVI program at his/her convenience, trips to the DVI site can be scheduled when they will be least costly in terms of conflict with work or travel costs.

The relatively high capital costs of DVI make it most cost-effective when it is used by very large numbers of students (preferably 1,000 or more) or can substitute for expensive and difficult-to-obtain expert instructors.

Like IVD, DVI may also provide certain cost savings. For example:

- DVI can reduce loss of productivity for training time, by having students use the DVI program when it does not conflict with work.
- DVI can offer simulated hands-on training in situations where "downtime" or damage to real equipment would be expensive.

- DVI can eliminate or reduce the need for expensive trips to field sites.
- DVI may be able to offer hands-on experience when mistakes in the real world are very expensive.

Although these types of savings may outweigh the cost of the DVI system and courseware, there is no body of DVI evaluations such as those for IVD, that document such savings.

Management requirements. DVI programs do not require an instructor to intercede between the training program and the student. Like other computer-based technologies, however, it does require a responsible person to manage the use of the technology and to resolve problems that arise. Generally these responsibilities are part of the role of the systems administrator who manages other microcomputers for the organization.

Management of dissemination of new DVI material is relatively easy, but it does require someone with sufficient computer skills to copy software from a floppy disc to the DVI system itself. Note: Editing DVI software is considerably more difficult and must be done by an experienced (and relatively expensive) professional.

The most difficult management challenge is to help instructors use DVI effectively in the regular training program. Like IVD, DVI programs help students learn to apply knowledge and to develop independent problem solving skills. This may conflict with the approaches used by instructors, who are accustomed to rote learning. In order for the DVI programs to be integrated effectively into the regular training program, instructors may require new attitudes about training. For such attitudinal changes to take place, changes in the incentive system and other management systems will be necessary.

Technical requirements. One of the advantages of DVI is that any program developed for a DVI system can run on any other DVI system. Currently, however, there are no standard configurations with standard features, and it can be difficult and time consuming to configure a DVI system that provides the desired capabilities.

This difficulty tends to dissuade even U.S. companies with considerable experience in training technologies from adopting DVI until the standards are more established. It is likely that developing countries would have even greater difficulty building effective DVI systems, as well as ensuring compatibility with future systems.

Routine maintenance for DVI systems is similar to that for ordinary microcomputers.

EDUCATIONAL TELEVISION (ETV)

Education television (ETV) is defined in this report as broadcast television that has been specifically designed to be part of a training curriculum.

Educational Television (ETV)

Advantages	Disadvantages
• Offers programs from many countries • Provides clear video (depending on broadcast signal) • Can reach large numbers of people with standardized material • Many existing programs available	• Does not provide immediate feedback • Generally poor for "hands on" training • Moderately expensive capital costs for equipment • Relatively expensive to revise • Not appropriate for vocational training for narrow audience • Requires broadcast infrastructure • Moderately high delivery costs for broadcasting

I. Capabilities and Considerations

Content-related. ETV can deliver an extremely wide range of high-quality instructional programs that would otherwise be too expensive or difficult for a developing country to provide on a local level (for discussion of distance education, see Block, et al. and Young, et al). ETV programs can either be created by the developing country itself, or transmitted to the developing country via satellite. For example:

- ETV can transmit training programs from other countries, presenting experts who otherwise could not be made available in the developing country
- ETV can guide students through difficult or dangerous procedures with equipment that is not available at the students' site.

With the use of video cassette recorders (VCRs), ETV programs can be videotaped off the air then played later at times that are convenient for the instructors and students.

ETV is especially appropriate for training programs in which clear video or photographs are important, such as medicine or biology. It is not, however, an effective way of presenting

simulated hands-on training, or of providing any type of interactive training program, except as a supplement to trainer-led instruction.

Mexico has used ETV for secondary and post-secondary education. Mexico's Telesecundaria System, for example, has provided secondary education to students who would otherwise not have access to it. Achievement gains have been approximately the same as those for students in conventional schools. Furthermore, there is evidence that disparities between achievement of rural and of urban ETV students is less than exists in conventional schools. It is estimated that this program will reach one million students by the year 2000.

China has used ETV to deliver university education. The Central Radio and TV University (CRTVU) produces and broadcasts programs, as well as distributing audiocassettes for selected courses. Students are generally 18 to 35 years of age, are employed, about half are skilled, and almost 40% are under-qualified teachers. It appears that approximately 70% of those enrolled receive degrees. These degrees, however, are not considered to be equivalent to regular university degrees — CRTVU students cannot apply to regular universities, and CRTVU graduates rarely attain salary rates equivalent to those who attended conventional college. CRTVU continues to expand the courses and enrollment, with many vocational courses to be added. Whenever possible, CRTVU uses existing polytechnical curricula for their ETV programs.

Evaluations of ETV have mixed results. Programs have shown excellent outcomes in some areas and poor ones in others. Even programs that appeared to be successful in raising educational opportunities and reducing repetition and dropout rates have sometimes been cancelled.

One advantage of ETV is that a large amount of material has already been produced in the developed countries and is available for transmission to other developing countries. In addition, there are large film libraries of organizations like UNICEF, WHO, and UNESCO, which can provide material for ETV programs. It is worth noting, however, that most of the existing material is for general education, especially secondary or university education, rather than for training in a particular skill.

ETV programs are moderately expensive to revise, with most of the cost related to the need for shooting new video or slides. As a result, ETV can be appropriate for material that changes moderately often (every two years) and may be more cost effective than other alternatives for material that changes relatively frequently (once or twice a year).

Skills development. Evaluations of ETV suggest that it is not a good stand-alone medium. To be effective, ETV needs to be combined with other media and extension services.

ETV, when combined with print and agricultural extension services in Africa, has been successfully used to inform farmers of new agricultural techniques and to train extension workers in those techniques. For example, programs in the Côte d'Ivoire, appear to have contributed to increased rice production.

But as is the case with other media, the effectiveness of ETV programs depends on the quality of the instructional design and its ability to communicate with and engage the audience.

Appropriate audiences. In general, ETV is not considered to be an appropriate technology for vocational training, particularly in areas where the content is specialized and relevant for only a narrow audience.

What ETV can provide, however, is instruction to a broad audience on general subjects such as new agricultural techniques or operation of new types of equipment.

ETV is generally considered to be most appropriate for secondary and post-secondary adult audiences. It is not appropriate for audiences that require repeated and/or ongoing training, particularly if audience skill levels vary.

Instructor resources. ETV can be valuable for situations in which qualified instructors are unavailable. For reasons that are not entirely clear, ETV appears to have generated considerable resistance on the part of teachers in many countries. As mentioned above, ETV often requires the involvement of an instructor or extension worker in order to provide training that alters behavior or teaches new skills.

II. Requirements

Hardware. ETV requires a television sufficiently close to the transmission point to pick up the signal clearly. In order to pick up programs transmitted by satellite, it is necessary for the recipient organization to have either a satellite dish or be within the broadcasting area of a station that can pick up a satellite transmission. (Satellite dishes can be obtained for as little as $5,000.)

Financial requirements. One problem faced by ETV is that all forms (cable, closed circuit, open transmission, microwave, and satellite) are expensive, and require large numbers of students to be cost-effective; yet often ETV programs must start small before it is possible to develop an audience of sufficient size.

Estimates of the audience size required for cost-effectiveness vary widely. One assessment of the operating costs for an ETV program was $500/student/science course/year (excluding costs of maintenance, capital costs of the equipment, cost of the building to house the course, etc.). For this course it was estimated that it required more than 200 students in order to be comparable in cost to other forms of instruction; when the program reached more than 200 students, the cost dropped considerably.

Other estimates suggest that for large audiences (1,000 or more), the per-student costs of ETV are comparable to those of IVD or CD-I. In contrast, other estimates suggest that audiences of tens or even hundreds of thousands are necessary over long periods of time (perhaps 20 years) in order for ETV to be cost effective.

Yet some programs have demonstrated that ETV can be cost-effective:

- An Ivory Coast ETV project cost less than conventional schools: $13/student/year (based on 336,000 students).
- Studies of the Mexico Telesecundaria system shows that costs are equal to or lower than those of conventional secondary schools.
- Korea's Air and Correspondence University shows an average cost of about one-tenth that of conventional universities.
- Pakistan's Allama Eqbal Open University delivers courses for about half the cost of conventional universities.
- Thailand's Sukhothai Thammathirat Open University delivers courses for less than one-fifth the cost of conventional universities.

As the cost of equipment — VCRs, televisions, solar-powered TVs, portable equipment, large-screen TVs — continues to drop, ETV will become more accessible to developing countries. Programs continue to be expensive to develop, however, although the number of "off-the-shelf" programs continue to expand.

Delivery costs for ETV are high because television broadcasting time is expensive.

It is also important to note that the problem of cost is exacerbated in some countries by the need for programs to "fit" different sections of the country that are culturally different. The result is substantially higher capital costs of program development along with smaller audiences for each particular program.

Management requirements. ETV programs are often difficult and complex to manage. Designing effective programs is challenging, and many developing countries lack professionals with solid experience in this area. In addition, there are cultural issues that must be addressed, and can be made more complicated when diverse cultures are represented in the country.

In contrast to general education TV programs, which often do not require a teacher, skills training programs may require an instructor to supplement the ETV training program. Managing that type of support is often difficult. Finally, it may be difficult to manage the relationship with local TV stations, and to ensure a regular broadcast slot for ETV programs.

In managing dissemination of new material, it can be difficult to ensure that the program will reach the target audience, and that supplementary support, such as access to an instructor, is available.

A major management challenge is to involve instructors effectively in the use of ETV. There are many cases in which developing countries have limited or eliminated the use of ETV because it generated strong resistance from teachers. Effectively involving teachers, and managing their response to ETV programs, is necessary for ETV to be integrated with other training elements that support development of new skills.

Technical requirements. Technical requirements include broadcasting stations large and powerful enough to transmit signals to a very large audience. There must also be television at sites, and repair services for those televisions.

The balance of the technical requirements focus on the quality of the video production, which is best left to professionals.

TELECONFERENCING

Like interactive radio and ETV, teleconferencing provides a means for reaching large audiences. It uses a phone line to create a dynamic link between instructors and students who are separated by distance.

Teleconferencing

Advantages	Disadvantages
• Provides immediate feedback • Offers programs from many countries • Audio-only systems are relatively low cost for training remote groups • Relatively easy to revise • Many programs available	• Difficult to provide visuals • Generally poor for "hands on" training • Requires coordination among multiple bureaucratic agencies • Requires telecommunications infrastructure

I. Capabilities and Considerations

Content-related. The major benefit of teleconferencing is that it adds an immediate interaction capability between instructor and students. It is the need for such interaction that justifies the cost of teleconferencing.

There are two kinds of teleconferencing: Audio teleconferencing (sound only) and audio-visual teleconferencing (sound and visuals). Audio teleconferencing links the instructor with the students by telephone. Audio-visual teleconferencing links the instructor with the students by telephone, but has the added capability of allowing visual materials to be sent over the phone line via slow-scan video, microcomputer, or fax machine to the other site.

Although many types of telecommunications systems are used for teleconferencing, satellite systems seem to be the most promising. Using satellite, it is now technically feasible to link virtually anyplace on earth to a telecommunications network. Even given these opportunities, however, it continues to be far easier to conduct audio teleconferencing than audio-visual teleconferencing. Thus, where visual information is key, and particularly where visual information must be presented clearly, teleconferencing is often not the best alternative.

The two-way communication system provided by teleconferencing provides considerable power to instruction. Teleconferencing can provide a variety of courses, from university courses, in-

service training, and health campaign information, to medical consultation assistance, and management conferences. In pilot projects using teleconferencing, the preferred courses seem to be in-service training and skills upgrading (see Tietjen).

In the U.S., audio teleconferencing systems allied with microcomputers for delivering graphics have been shown to be economical and easy to maintain. However, experience in developing countries suggests that although the phone linkages can work effectively, there are often problems with the supplementary graphics or other equipment to deliver visual information. But, as the technologies improve, it may become increasingly feasible to add microcomputer transmissions to teleconferencing in developing countries.

Three pilot projects, in Indonesia, the West Indies, and Peru, for example, linked remote universities and professional agencies with one another and with experts at central points.

The project evaluations concluded that although face-to-face instruction is preferable, teleconferencing can provide excellent instruction. In those projects, teleconferencing proved capable of delivering high-quality instruction to university classes and to working professionals at acceptable costs. There was widespread positive response by both instructors and students.

In Indonesia, for example, 67% of students and 95% of local tutors reported that teleconferencing instruction was as effective as regular courses. They also testified to the importance of the interaction between students and instructors.

The West Indies teleconferencing system (UWIDITE) provided professional training to small groups of adults in isolated areas. As was the case in Indonesia, the response from students was very positive, with 68% reporting that the telecommunications class was as effective as the regular classes.

Peru's PCSP provided audio conferencing for in-service training. More than 92% of the participants reported that the program improved their skills and job performance. 99% requested that additional seminars be offered. More than half said they had received crucial information and training that they would not otherwise have been able to receive. In 1985, the program delivered more than 300 teleconferences at field workers' request.

Skills development. Teleconferencing programs generally have not provided simulated hands-on training. They have also posed difficulties in actually enabling students to ask questions of the instructors. Nonetheless, teleconferencing appears to be effective in teaching technical and in-service professional skills that will be practiced later by the students. Some professionals also argue that, given the right design, teleconferencing can provide some "hands on" training.

Appropriate audiences. Teleconferencing appears to be most effective for students who are relatively mature and take responsibility for attending classes and actively learning the material. Thus, teleconferencing courses are most successful for university students or for those seeking in-service or professional training — i.e., adults who can work largely independently. Generally, the audience should not vary greatly in skill level.

Teleconferencing usually delivers its greatest value in situations where students are in rural or remote areas and have difficulty reaching the ordinary sites for courses. It does not appear necessary to have very large numbers of students in order to justify the costs of telecommunications courses.

Instructor resources. Teleconferencing is best justified where immediate interactive communications between students and instructors is important but limited resources make it difficult for students to travel to classes or for instructors to travel to student sites.

To be successful, teleconferencing requires qualified instructors who understand how to teach over this medium. It also is important that tutors or other teaching assistants are available at the teleconferencing classes to help participants use the technology effectively, and facilitate discussions that complement the teleconferencing courses.

II. Requirements

Hardware. Successful teleconferencing depends on an accurate assessment of the level of existing resources, particularly local telecommunications lines. The telecommunications lines must be able to carry dependable, reasonable quality signals without too much "noise."

Audio teleconferencing systems generally include receivers, microphones and, usually, loudspeakers. They are far less expensive and far easier to manage and maintain than audio-visual systems. Audio-visual systems can include television, telewriters, microcomputers, fax.

Financial requirements. Capital costs for teleconferencing vary widely, depending on whether the system is audio only or audio-visual, and the capacity of the system. The use of video raises costs substantially.

Video adds costs in two key areas:

- Course preparation. It is far more expensive to produce audio-visual material than simply audio material.
- Satellite transmission costs are far greater for video than for audio — on the order of twice as much.

The type of two-way communications also affects the cost of the system, e.g., the use of satellite, microwave, cable, etc. All systems, however, require regular maintenance.

Although costs vary widely, several evaluations of teleconferencing programs indicate that telecommunications often provides instruction at lower cost than physically transporting instructors to students or students together for a class.

For example, one project found that the average cost of an audio teleconference, involving three to four sites and about 20 people cost about $370 or $20/participant-hour. Excluding the technical assistance costs, the average cost of the teleconference was $8/participant hour. (see Mayo)

This study also showed that although telephone use was far greater than expected, revenues from telephone calls and fees for the teleconferencing programs could not cover operating costs of the telecommunications system in the first two years of operation. However, they did cover nearly 90% of annual operating costs by the end of the second year, with expectations that revenues would continue to expand.

Other programs show teleconferencing costs to be lower than face-to-face teaching (e.g., $6,000 vs. $19,000 for a one week seminar for 30 people; $11 vs. $64 per student for a visiting professor program). (See Tietjen.)

One cost estimate is that a satellite link for a single point is $15,000 to $20,000, including all components (satellite dish, monitor, computer, VCR) necessary where no phone lines exist.

Delivery costs are also relatively high, including the cost of the student to travel to the site of the teleconferencing course, the cost of the course facilitator, and the cost of transmitting the course. Of course, the larger the audience, the more cost-effective the course. One approach is to share a satellite link among multiple courses, thus bringing costs down for all of the courses. However, it appears that teleconferencing can be cost-effective with moderate numbers of participants (on the order of 200-300).

Management requirements. A major management challenge is to bring about good coordination and cooperation among different government agencies involved in a telecommunications program delivering training. Thus, management of teleconferencing is a major challenge and requires strong leadership at the center of the network.

It is important to ensure that the Public Telephone and Telegraph authorities are involved in the technical planning even if they are not in charge of the program.

There may be commercial users sharing teleconferencing systems with education and training programs in order to generate revenue to cover the costs of the system. These programs must also be coordinated with the training programs.

In addition, careful management between the central source of teleconferencing programs and the local training institutions is necessary in order to ensure that courses reach students in a consistent and well scheduled manner.

It is important not to assume the basic elements are in place, e.g., that instructors will show up on time. There may also be a need to improve coordination among local institutions, which may not have standard practices, e.g., with regard to when courses start, testing, etc. Also, a major management problem is ensuring that support materials, including text books, are available to students in a timely manner.

All of these management requirements strongly indicate that those participating in delivering a telecommunications program require training. Faculty may need training in designing and delivering courses appropriately for the medium. Education designers and administrators will

require training in the features and requirements of the system. Telecommunications staff need training in new technologies and the needs of training programs.

Technical requirements. In general, teleconferencing seems to be quite reliable, especially if the project uses simple and sturdy equipment (e.g., loudspeakers and microphones). One project showed a 90-98% reliability (see Tietjen). Nonetheless, technical requirements for running teleconferencing programs are quite high. For teleconferencing programs carried by satellite, technical problems that arise are generally associated with local telecommunications lines rather than with the satellite link, or with end-receiving equipment, e.g., loudspeakers. In the words of one report: "The 44,600 miles to the satellite and back will probably be less problem than the last mile of cable from the satellite network to the classroom." (see Tietjen)

The most problematic components of the system are visual receivers, e.g., microcomputers, slow scan TV, and even fax. At a result, a basic rule of thumb is to start as simple as possible, and build complexity with experience, and as needed. It is safer to use simple, commercially available technology rather than new, prototype equipment.

In addition, it is important to note that two-site links may not demonstrate the quality that will be produced by multi-site links, where there are more likely to be problems with "noise" on the lines and severed connections.

It may be possible to run receivers with solar or with battery power. In Indonesia, for example, a satellite earth station and audio conferencing equipment used photovoltaic cells and ran on approximately the power needed for a steam iron.

Technical requirements for this medium are varied and complex, and detailed discussion is beyond the scope of this report. It is worth noting again, however, that it is far easier to ensure proper performance of audio equipment than audio-visual equipment, and for many topics the latter is unnecessary. Slow-scan video and other visual equipment is both expensive and often fails to function properly on developing country telecommunications systems. Field testing of such equipment under realistic conditions is essential.

RADIO

Radio has long been accorded recognition as an highly cost-effective education technology. It reaches large numbers of people at a relatively low cost, leveraging the enormous established base of radios that already exists in developing countries.

Radio

Advantages	Disadvantages
• Interactive radio offers immediate feedback • Relatively easy to revise • Reaches wide audiences • Reaches remote groups at relatively low cost • Many existing programs available • Relatively easy to revise • Can be used with low skilled facilitator rather than instructor	• No visuals • Feedback is highly structured • Generally poor for "hands on" training • Not appropriate for training small audiences • Generally poor for complex instruction • Requires broadcasting station

I. Capabilities and Considerations

Content-related. There are two basic types of radio instruction:

- Regular broadcasting of instruction
- Interactive radio instruction, which incorporates instruction, active participation, and reinforcement of correct answers. (Interactive radio designs programs with pauses for student responses. After the pause, there is feedback that corrects an incorrect response, and reinforces a correct one.)

With the use of a tape recorder and audio cassettes, radio programs can be taped and played later at times that are convenient for the instructor and students.

Evaluations of training by radio — particularly interactive radio — have been extremely positive, indicating that this approach can help to improve education quality and expand access at relatively low cost. In general, it has been more successful than ETV, largely because the programs are simpler to develop and the maintenance of the infrastructure is cheaper and easier.

Most of the studies of interactive radio (IR) examine its use in classroom situations. Evaluations of this use indicate that IR can significantly improve student achievement in a variety of subjects. Some examples include:

- The Thailand Radio Mathematics Experiment (grades 1-3) raised student math achievement significantly, and reduced disparities between rural and urban students.
- A Guatemalan education radio project substantially reduced dropout rates among the Shuar.
- The Kenya Radio Language Arts Program showed that the interactive radio program was significantly more effective in raising achievement than were textbooks.

Radio — especially interactive radio — has been used to:

- Raise the quality of conventional instruction by adding "enrichment" material.
- Deliver complete courses where a trained teacher cannot do so.
- Deliver most of the instruction, supplemented by a paraprofessional.
- Deliver instruction outside classrooms, where the student works largely independently using radio, other materials, and occasional classes.

Radio is usually more effective in delivering total courses than in providing "enrichment" for regular classes. The use of radio, especially IR, to teach a complete course is particularly valuable for classrooms in which there are multiple grades. The teacher assigns one age group to listen to the radio program while he/she is teaching another age group.

These programs also indicate, however, that interactive radio is far more difficult to design successfully for situations in which answers can be longer and more complex. Nonetheless, radio for adult education appears to have been quite successful in delivering instruction in many areas, including vocational training topics, agricultural extension, adult literacy, health programs, nutrition programs, and family planning. In Nepal, for example, the Radio Education Teacher Training Project was highly successful, with participants scoring 25% to 50% higher than those attending regular classes.

IR programs that deliver complete courses have also been used effectively to train teachers to teach those courses. The radio programs "model" effective teaching methods, which the teacher eventually learns to conduct independently.

For effective delivery system of vocational or technical training, radio appears to require supplemental material, e.g., work sheets or other printed material. Supplementary materials need to be short so students will actually use them. With the use of such material, radio appears to be effective in teaching general topics such as marketing. It is less appropriate for specialized technical training targeted at a narrow audience, because it requires large numbers to be cost-effective. It is also less appropriate, of course, for material in which visual information is important, especially if print pictures do not provide the necessary experience or information.

Skills development. Radio has been used for vocational training, especially for areas or groups who otherwise would not have access to training. Agricultural training programs delivered over radio have been quite successful. In Malawi, for example, one project evaluation found that radio trained farmers in new agricultural techniques at costs 3,000 times less per hour than face-to-face extension services.

Yet radio appears to be more effective in conveying information about techniques than in developing new skills among students or teaching them to how apply new techniques. Thus, for some skills, e.g., accounting, using radio along with print materials and exercise may be sufficient. For others, hands-on experience or instructor-led instruction must supplement the radio instruction.

Appropriate audiences. Radio is most appropriate for "captive" audiences, e.g., classroom students, or for those who are highly motivated. Studies of university radio education for adults also suggest that adults who are relatively successful in such programs tend to be better educated and wealthier than those who do not complete such courses successfully.

Although radio instruction is cost-effective, it is most appropriate for content directed toward large numbers of students over a period of time. As a result, most programs tend to be fairly general in order to appeal to a large audience.

Instructor resources. Because most radio programs require supplementary classes, instructor resources are required for vocational and technical training.

Successful interactive radio programs also provide short guides to help teachers prepare for lessons and conduct post-broadcast activities. In addition, complementary radio programs are used to help strengthen teachers' skills in language arts, mathematics, and science.

Radio can be helpful in teaching basic skills and freeing instructors to teach more advanced courses, thereby helping make more effective use of faculty.

It is important to note that existing radio programs may have to be modified for particular cultural contexts in order for them to be effective.

II. Requirements

Hardware. Radio programs require radio receivers and radio stations close enough to transmit clear signals to students. In all developing countries, radios are widely available and relatively inexpensive.

Financial requirements. Although radio is cost-effective, it does require substantial investment in large numbers of radios, courseware development, and the cost of transmission. Financial resources must be sufficient to plan, implement, and institutionalize the radio instruction program.

Nonetheless, radio can help reduce or at least slow the increase in education costs. Per student operating costs have been calculated at $.40 to $3.00 per student/course/year. This is very close

to the cost of textbooks. The use of print material (texts or workbooks) enhances effectiveness and is still inexpensive — $20 to $40 per student/course/year. However, these estimates *exclude* the capital costs of instructional development, which can be $1 million, $2 million or more over a few years. They also exclude the cost of instructors or para-professionals, who are usually necessary.

One way to cut costs without sacrificing quality is to adapt proven radio education programs for different audiences. But, as stated earlier, it may be necessary to modify an existing radio program to fit a particular cultural context.

Another cost-cutting measure is to develop reusable supplementary materials in place of disposable worksheets.

Management requirements. Radio education programs do require substantial management skills. Programs must be designed and produced, print materials must be delivered, and in some cases, radios must be provided. Those running the programs must be able to interact effectively with local, national, and international organizations.

Instructors' roles are particularly important because often the instructor's role changes with the use of radio. Rather than instruct students, for example, the instructor may have to prepare students for the radio program, review and explain the materials presented in the program, and conduct activities that reinforce what was learned and apply the material to actual situations. Given the complexity of this role, instructors may need training in carrying out these tasks.

Despite the apparent success of radio education programs, they are not widely used in developing countries. The reasons are not clear. It may relate to resistance from the existing education system, technical problems with weak radio signals, or financial problems with recurrent costs. Whatever the problem, however, it will require a high level of management skills to identify the obstacles and to overcome them.

Technical requirements. In addition to the obvious technical requirements of power sources and equipment maintenance services, radio programs require special technical inputs. Most important is access to radio transmission facilities during times appropriate for the lessons, and at reasonable cost. It is also necessary to ensure that transmission signals are clear to all those receiving the programs.

In some cases, educational radio has its own independent facilities. In others, the stations are owned by the government. In most countries, however, the education radio programs must rent commercial stations, and scheduling can be difficult.

Where the programs are broadcast to schools, the problems may be overcome by distributing tape recorders to schools, so that instructors can record the program then replay it at appropriate times for instruction. In most cases, however, the only feasible solution is to work out an acceptable arrangement with the commercial station.

VIDEO CASSETTES (VCR)

Video Cassette Recorders (VCRs) and video cassettes make video training programs readily available to groups who are not served by an ETV network, or those who cannot be served at times that are convenient for instructors and students.

Video Cassettes (VCR)

Advantages	Disadvantages
• Offers programs from many countries • Provides clear video • Can deliver standardized material to remote or scattered groups • Many existing programs available • Appropriate for vocational training for narrow audience • Can substitute for trainer	• Does not provide feedback • Generally poor for "hands on" training • Moderately expensive to revise • Relatively expensive to distribute • Relatively high capital costs

I. Capabilities and Considerations

Content-related. VCRs offer the same wide range of high-quality instruction available via ETV but with a number of distinct advantages. Use of VCRs expands the technical and professional training programs that can be made available because, in contrast to ETV, VCRs can deliver video programs cost-effectively to small groups of students. They can also provide programs to groups that are beyond the signal of ETV broadcasts. In addition, the visual signal is higher quality and more reliable for VCRs, making them more appropriate than ETV for programs that require very clear visuals.

Thus, VCRs provide easy and flexible access to the large amount of video training material distributed by private and public sector organizations in developing and developed countries. In addition, video cassettes are available from large film libraries of organizations such as UNICEF, WHO, and UNESCO. Directories such as the *Educational Film/Video Locator* can be helpful in identifying currently available film and video programs. Private firms that specialize in industrial training also have libraries of generic videotapes for a wide range of technical training.

Unlike ETV, video cassettes can be interrupted for instructor-led discussion, as well as easily reviewed in whole or in part to reinforce particular training points. For integration into an

instructor-led course, short, single concept video programs are generally more flexible than more elaborate programs.

Video cassettes have advantages over other linear (non-interactive) media as well. In contrast to radio instruction, for example, video programs are appropriate for teaching complex material (for discussion of the importance of visual material, see Vella).

As compared with film, video can be produced more quickly and with far lower production costs. In addition, developing countries are more likely to have facilities to produce video programs than film. For delivery of the programs, VCR and television equipment are much easier to use than are film projectors.

In contrast with ETV, video cassettes can be interrupted by the instructor so that points of instruction can be discussed among the trainees. Like ETV, video cassette programs are only moderately expensive to revise, new versions can be developed relatively quickly, and revisions can often be made in developing countries.

Distribution of instruction using video cassettes is, however, more complex than using ETV. In general, video cassettes are appropriate for material that changes moderately often (every two years) and may be more cost effective than other alternatives, including ETV, for material that changes relatively frequently (once or twice a year).

Skills development. Like ETV, video cassettes are not an effective way of presenting simulated hands-on training. Nor do they provide interactive training, other than the interaction created by an instructor who interrupts the program for questions or group discussion.

Although video cassettes are generally not effective for teaching students to alter existing ways of doing productive activities, they can do so if they are part of a comprehensive training package, or are combined with supplementary services such as extension services. Like ETV, the effectiveness of video training programs depend on their ability to communicate with and engage the particular audience.

Appropriate audiences. In contrast to ETV, which requires large numbers of viewers for each program, video cassettes can be appropriate for vocational training, even where the content is specialized and relevant for only a narrow audience.

Video cassettes can also reach audiences that are beyond the reach of ETV signals, or for whom the program is transmitted at an inconvenient hour. Cassettes are not as appropriate as ETV, however, for instructing a very broad audience on general subjects such as new agricultural techniques or operation of new types of equipment.

Video cassettes are particularly useful for dispersed populations, where it is only possible to gather small groups at one site. In contrast to ETV, cassettes can also be appropriate for audiences that require repeated training.

Instructor resources. Video cassettes can provide instruction where qualified instructors are unavailable. In general, however, video programs that aim to alter behavior or teach new skills require the involvement of an instructor or extension worker.

II. Requirements

Hardware. Video training requires a VCR and a television set. Although televisions are expensive, they are already widespread in many developing countries. VCRs and camcorders are also becoming more widely available in developing countries. These trends are likely to continue.

Financial requirements. While less expensive than IVD, DVI, and CD-ROM systems, VCRs and televisions are still costly for developing countries. Yet they can provide cost-effective training for small groups by ensuring that the total number of individuals in all the groups is sufficient to justify costs of the equipment.

Video cassette training can also start small, providing programs to limited groups, unlike ETV which must have large numbers of viewers for each program in order to be cost-effective. In addition, video cassettes offer a cost effective means to provide video programs that "fit" the special cultural needs of different parts of the country, even where the audience in each area is small.

As the cost of VCR and television equipment continues to decline, video training will become more accessible to developing countries. Production of video programs will continue to be expensive, however, and the use of "off-the-shelf" programs is likely to expand.

Without the expense of broadcasting, delivery costs of video training programs are relatively low, involving only the cost of the student to travel to the VCR site.

Management requirements. Much of the management challenge of video training programs relate to ensuring that the programs are appropriate for the target audiences, that instructors use the programs effectively, and that video training is well integrated into the overall training program.

Another management challenge involves ensuring that the training programs reach the target audience in a timely manner and in good condition.

Technical requirements. Most of the technical demands for video training relate to the design of the programs and video production. VCR equipment is easy to use, and can be handled by a responsible, non-technical individual. However, it is generally advisable, to assign one individual responsibility for ensuring that the VCRs are used properly.

Repair services are also necessary for VCRs and television sets.

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