World
Meteorological
Organization

Notes for the training of instructors in meteorology and operational hydrology

Part I

G. M. Rudder (Editor)
B. Heckman
C. Duncan

Education and Training Programme
ETR-16

March 2001

WMO/TD N° 1058

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PART I

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PREFACE

One of the overall objectives of the WMO Education and Training Programme relates to the promotion of capacity building by assisting NMHSs in the attainment of an appropriate level of self-sufficiency in meeting their training needs and developing their human resources.

The availability of well-prepared, skilled and knowledgeable instructors in order to fulfil this objective is an evident need. Accordingly the Programme includes within its activities the implementation of periodic regional training seminars addressed to national instructors. Moreover, the WMO Twelfth Congress (Geneva, 1995) expressed the wish to have training publications prepared, among others, on the subject of training of instructors.

The present publication arranged under the guidance of Mr Geoffrey M. Rudder as main editor, aims at helping the meteorological and hydrological instructors to up-date their know-how on teaching methods, strategies and technologies. We hope that the text will also serve as a guide and reference to both new and experienced instructors.

We wish to convey our gratitude to all the contributors and the Editor for their generous cooperation and the excellent work they have done in producing this publication.

(G. V. Necco)
Director
Education and Training Department

INTRODUCTION

Purpose and Objectives of the Education and Training Programme

A recurring objective of the Education and Training Programme (ETRP) under the WMO Long Term Plan is to ensure the availability of adequately trained staff in Member Countries to meet their responsibilities for providing meteorological and hydrological information and services. The other two objectives of the ETRP also require the availability of trained personnel of suitable quality and in adequate numbers. A very important factor upon which the attainment of these objectives rests is the adequacy of those persons who will actually train the required staff members, or in other words, there is a need for highly trained instructors or trainers. This need for trained instructors can even be extrapolated upwards to impinge upon the fulfillment of the very purpose for which the Programme was established, that being to assist Members, in particular developing countries, with ultimately developing self-reliant capabilities.

The WMO approach to Education and Training

The WMO approach to education and training is multi-faceted under a Programme structure of four sub-programmes, but only those aspects or items that are pedagogical in nature and relate to instructor training need to be considered here.

Under the ETRP, the training of instructors is carried out or supported under activities such as:

- The training of trainers and instructors is a specific project dedicated to this purpose. Along with the project for the training of operational personnel in special subject areas, instructors can be trained in relevant courses on the theory, principles and practices of teaching methods. They can also obtain experience by attachments to established training institutions.
- The preparation under the ETRP of relevant training publications and materials for use in National Training Institutions and in the WMO Regional Meteorological Training Centres. This publication is an example and product of this type of activity.
- The availability for use by Members' training institutions of training materials, in particular audio visual and computer materials, in the WMO Training Library of the Education and Training Department. This facility now includes the Virtual Training Library page among WMO's web pages from which its resources are available for free downloading.
- Participating in the Exchange of Training Knowledge activities of SCHOTI (*) and the sharing of information on new training techniques and technologies.
- The utilization by RMTCs of the roving experts and visiting scientist activity for the benefit of their instructors.
- Training under the WMO Fellowships Programme.

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* *SCHOTI: Standing Conference of Heads of Training Institutions of National Meteorological Services.*

The Purpose of this Publication

The purpose of this publication is to:

- Enable instructors, in particular those at RMTCs and National Training Institutions in developing countries, to upgrade their knowledge in the methodology of teaching and to enhance their skill in training strategies and technologies.
- Serve as a guide and an aid to the untrained inexperienced instructor.
- Serve as an aid to the instructor with some training and limited experience.
- Serve as a reference to the trained seasoned instructor.
- Serve as a guide for those responsible for the training of instructors.

About this publication

This publication consists of two parts.

Part I

Learning theory

In the last decade or so meteorologists and hydrologists had to become multi-disciplinary scientists, and likewise the trainers in these fields must embrace more and more of the concepts of 'education' as a discipline. It is now accepted that the degree of success of instructing is enhanced by the application of certain educational concepts, two of which are Instructional Design (ID) and Learning Principles. Accordingly, the main purpose of Chapter 1 is to provide an overview of the Instructional Design Process and show how it relates to learning and teaching. It aims to provide instructors with a working knowledge of ID concepts, procedures and models that will assist them in planning, developing and executing various instructional activities.

Training Delivery

The instructor is in the front line for carrying out the training and must therefore be fully competent to perform this task. This is the main and most practical subject of the book as it has to do with two actions, training by the trainer and learning by the trainee. Chapter 2 sets the theoretical background by presenting instructional strategies that are based on Learning Theory, and aims to provide instructors with basic knowledge and skills in developing and delivering actual lessons which require the use of up to date learning principles. This is emphasized through the comparison of traditional, that is older, and modern learning principles. The Chapter contains a number of simulated training institution scenarios to explain the application of the principles involved.

Chapter 3 continues the modernization process through the use of Educational Technology in the delivery of training. It points out that the instructor does not have to choose between conventional and technological approaches for training delivery, but would find that a suitable mixture is usually the best approach. The Chapter provides a comprehensive coverage of relevant facilities and equipment, but it should be borne in mind that such technology, in particular electronic, is constantly advancing.

Chapter 4 supplements the consideration of Training Delivery by leading the instructor across the gap between theory and practice. It starts with traditional classroom lecturing and moves on through situations where the trainees do more and more self-study with consequential less involvement of the instructor, logically finishing up at open and distant learning types of training. It deals briefly with some aspects of evaluation, and the management of open and distant learning.

The Annex

The Annex to this publication contains references to materials for training the trainer to enable instructors to undertake their own do-it-yourself training from their offices and institutions. It is intended that the Annex will be a living entity with periodic updating and expansion both in terms of its content and its medium, or media, of presentation.

Part II

Training Management and Development

The instructor must know enough of the principles and concepts of training management to function efficiently as part of the overall training team in the training institution, as well as to be able to manage his/her own training portfolio. The instructor may not have a responsibility for training development but must understand enough of this subject to be able to participate in this process as will undoubtedly be necessary. These concepts are dealt with in Chapter 1 of Part II from the institutional and operational service points of view, as distinct from the pedagogical approach to them in Chapter 1, Part I.

Training Evaluation

The instructor is the first line evaluator and must be competent to do this for his or her own purposes. The instructor must also work with and assist the training developer and training manager with the levels and forms of evaluation that they require. Evaluation is an essential and integral component in the entire training process, and is treated in Chapter 2.

4. Compare the activities associated with the instructional design process with those that typical senior instructors already use, but look at them from an instructional design process perspective.

Some suggestions boxes labeled, *FROM HERE TO THE CLASSROOM* will be introduced to help the reader step from the text to the classroom.

1.3 Applications of concepts, principles, and techniques

Before investigating the basic concepts and principles, and some applications of the ID process, let's first consider some situations in which the materials in this chapter might help.

If you are having difficulties in this area:	***Then, the ID process might help by guiding you in this direction…***
Your students do not see the relevance of the content that you're teaching	*You might consider changing from a concept lesson design to a performance oriented approach—how can learners apply what you're teaching?*
You test students frequently, but the results so far indicate that they're lost in the complexity of the content	*You might consider organizing your lessons using specific learning objectives and design tests around these objectives.*
You find yourself "testing" new educational technologies, but your students say, "You're using technologies just to be using them—we don't get it!"	*Develop a set of criteria for using the technology based on how they will help the learners to learn, or you to teach. Identify instructional problems that the technology can help solve.*
Your students seem bored in class…	*Consider conducting an evaluation of the course prior to the end of the semester—find out what's wrong. Or you might try moving from an instructor-centered classroom to a student-centered, active learning environment—make the students active participants in the their learning (see Chapter 2).*
Your students indicate that they're supposed to study one thing, but tests and other evaluations are about something else…	*You might consider integrating lesson objectives, instructional units, and tests. Tell the students what you want them to be able to do following the lesson.*

Table 1.1 Some potential challenges faced by classroom instructors and ways that the concepts and principles of the instructional design process might help.

1.4 How do learning, instruction, teaching, and the instructional design process compare?

How do we distinguish between learning, instruction, and teaching? What role does instructional design have with these concepts and processes? First, we'll discuss learning, instruction, and teaching, then show how these processes might be improved through the application of the ID process.

Figure 1.1 shows the relationship between these processes. If we view the learner at the center of the overall process, we see that learning is a *process completely controlled by the learner*. These processes take place within the learner's circle of learning. Whitrock (see (Good &

Brophy, 1986)) a leading educational psychologist defines learning as a *change process accomplished through experience.* He further explains that the change acquired is long lasting and relates to understanding, attitude, knowledge, information, skill, or ability. From this definition, we conclude that learning is an internal process accomplished through cognitive or mental processes and experience. It is for these reasons that learning is at the center of the learner-instruction process (Figure 1.1) which indicates that the learner controls her or his learning, not those of us involved in training or education. This does not mean that teaching does not significantly contribute to learning—it does, but those of us in the training and education profession must put our tasks in the proper perspective of the learner.

Let's look at the two contrasting examples of "learning" by a student taking our first year synoptic course.

> ***Example 1:*** *You've spent hours developing a lecture and discussion on the energy sources and developmental processes of tropical cyclones. About half way through the lecture, you notice James, one of your brightest students, in a sort of daze, as if he isn't thinking of the finer points of the lecture. Come to think of it, he's not asked many questions during this vital lesson. You think, however, that James has just been absorbed in the lecture and he's taking it all in. On the end-of-lesson quiz, however, James scored only 60%.*
>
> In contrast, we look at another example of learning with the following scenario.
>
> ***Example 2****: Two days later, you and James are at a social for the department where school talk is discouraged, but James asked about your experiences flying typhoon reconnaissance. He asks about how the crew estimated surface winds, the workings of the dropsonde, and how the data you collected related to initial storm formation. The next day in school, you overhear James enthusiastically telling another student how meteorologists flying aerial reconnaissance flights collect data that help determine a storm's intensification pattern. In fact, James tells his school mate he wants to take a flight so he can better understand why tropical storms form!*

In which situation is learning taking place—in the formal, school setting or during an off-handed conversation about another person's experience? In this situation, any long-term change started within the learner's circle of learning as shown in Figure 1.1. Learners learn from a variety of sources, as shown in Figure 1.1, including their family and friends, their own experiences, other people, and of course formal education and training settings. In summary, learning is an internal learner process which takes place not in a clean, linear fashion, but as Kemp, Morrison, & Steven (1998) suggest in a haphazard fashion. Now, let's take a closer look at teaching and instruction.

1.5 Teaching and Instruction

If learning is haphazard and controlled by each individual learner, instruction and teaching are planned and intentional (Kemp et al., 1998). Readers of this text certainly recognize this, but one of the purposes of this text is to provide the novice instructor with suggestions and guidance on how to more effectively and efficiently teach a well-designed instructional unit. For experienced teachers, our goal is to provide a refresher of things they already know and perhaps a slightly different perspective on instruction and teaching.

Much of our high quality "learning" occurs during childhood, outside of school—we simply were participants in the world around us (this is one of the major themes of the cognitive learning concepts or constructivism). In addition, on-the-job training (OJT) is a form of unstructured or less structured relative to the classroom environment in which the neophyte observer or forecaster learns from a more experienced person.

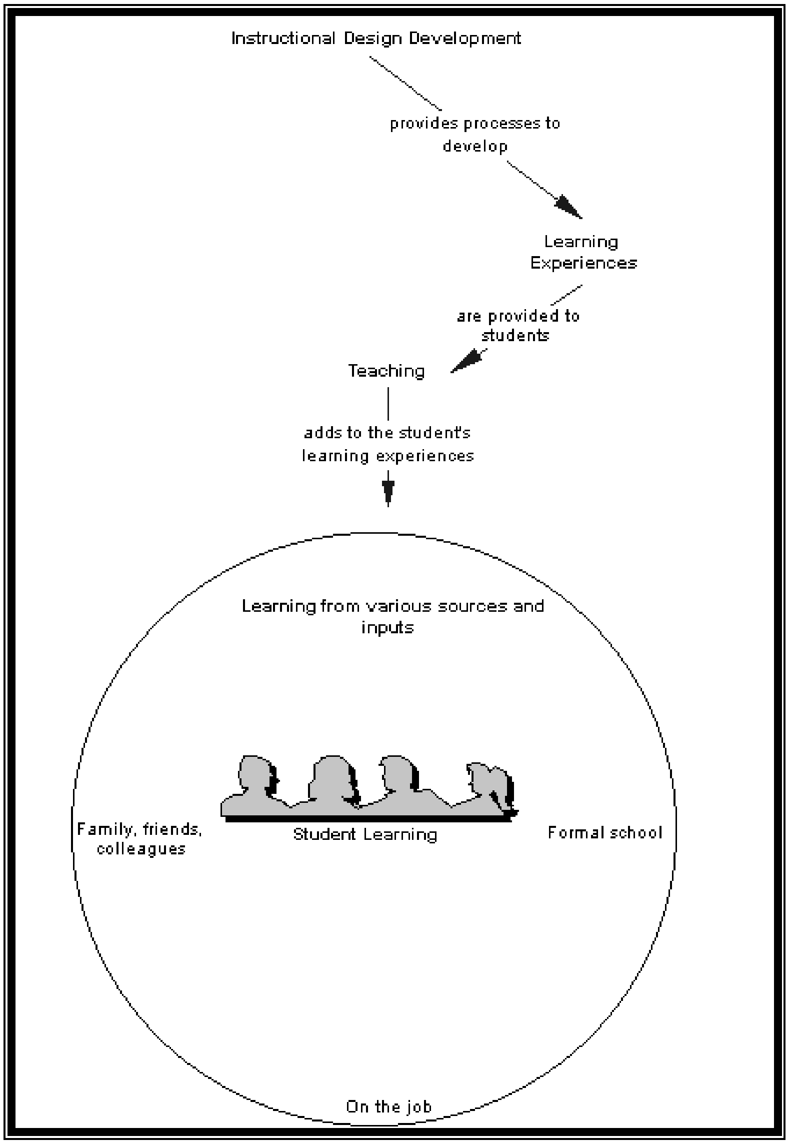

Fig 1.1 Relationship between learning, teaching, instruction and the instructional design process.

Instruction is quite different from learning. Gagné, Briggs, & Wager (1992) indicate that "instruction is a human undertaking whose purpose is to help people learn." Is instruction the same as teaching? Not really, for instruction can take place without an instructor and in fact the authors of this text devote ample space to the idea of learners teaching themselves. Teaching, per se, is but one of the vehicles which students can use to learn, but ob
viously a very important one. Gagné stresses that by using the instructional design process, we should consider all avenues of learning, not just the one with which we're most familiar and comfortable.

A few examples of activities in the classroom will provide a comparison between learning and teaching.

Classroom Situation #1*: An instructor at a RMTC in RA IV is lead instructor for the initial Tropical Meteorology course. He is providing lectures on the energies (a good strategy for the topic) of the tropical circulation patterns. In this case, our instructor is teaching and we* *hope the students are learning the material, as they will be tested on it shortly. Our students will judged on how much they learned when we test them and ascertain their behavior has changed from not knowing the material to being able to describe the energies associated with the flow patterns.*

Classroom Situation 2*: Students enrolled in a similar Tropical Meteorology course in a RMTC in RA I have been assigned to complete, in teams of two, Satellite Meteorology in Africa, Volume 2: Integrating Satellite Meteorology of the ITCZ into Analyses, developed by instructors at RMTCs in RA I. In this case, students are teaching themselves (cooperative learning, (see discussion in Chapter 2) the skills of using satellite imagery to interpret the ITCZ and associated cloud patterns. Their learning will be judged by tests given by the instructor for the course, and more importantly, by their performance in the forecast office following graduation.*

Classroom Situation 3*: Our next situation is where a team of students from the Tropical Met course have been assigned to study and lecture to their classmates on Observation and Analysis Techniques Used in Remote Regions. The teaching team has been coached by the instructor for two weeks on the key issues and has also researched, on its own, many of the references provided by the instructor. During two class periods, the students teach students the concepts, techniques, and show examples of how satellite data, ocean-going buoys, and remote land/island observations are used to observe remote regions of the tropical oceans. In this case, students teach and students learn from each other. The instructor, rather than teaching, has developed instruction for students to teach students. Learning takes place in two ways. First, each member of the teaching team learns from the coaching activities provided by the instructor (not lecture, but experiences and informal dialogue). Second, the students learn by exploring the numerous references provided by the instructor. Third, the other students of the class learn from their fellow students, just as they might from the instructor. It is possible that the class learns more from this activity than from the instructor simply lecturing students. We'll discuss this instructional technique in Chapter 2.*

Classroom Situation 4*: In our last situation, the instructor has arranged for two students to participate in intern programs at two Meteorological Service offices. Both students, as part of their senior year, are to work, on the job, at the Met Services for two months during the long summer break. They will receive credit for these interns, but are required to conduct seminars for their fellow students upon return. In this case, our two students learn through experiences gained while working with operational forecasters in a real-world environment. Formal teaching is not in the curriculum; rather, learning takes place in an authentic, real-world environment. When they return, however, their fellow students will learn through their teachings about their experiences while on the internship.*

These examples clearly point out the differences between learning and teaching. Students learn through many experiences, only one of which we, as instructors, teach them. This does not diminish the value or effectiveness of teaching, but does suggest that instructors should consider a variety of instructional techniques and experiences by which students should learn. The major points regarding learning, instruction, and teaching are:

- Learning is student-controlled and unplanned.
- Instruction is a planned process that provides opportunities for students to learn
- Teaching is generally planned and is one of several learning techniques.
- Students select the ways they learn, not administrators or teachers. And,
- Students have favored learning styles.

***FROM HERE TO THE CLASSROOM**: Conduct this self-survey. Think of three teaching methods that you routinely use in the classroom. Now, change places with your students and ask yourself: "How is learning facilitated by these methods?" Do I learn effectively using these methods? I used them in earlier learning situations, how did I feel about them then?*

As stated earlier, Gagné et al. (1992) and Kemp et al. (1998), state that instruction is a planned activity accomplished by instructors. It is the process that instructors follow that is the focus of the next section of this chapter. As we will see, this author feels strongly that instruction and teaching can be improved by following a systematic process of instructional development called *instructional design.*

1.6 Instructional Design Process

As teachers and instructors, we deliberately plan curricula, courses, and lessons so students learn effectively through processes that are efficient for us. The amount of time for planning varies, but the process that we follow is hopefully a systematic rather than haphazard (from the author's personal experience, it seems like some lessons are more haphazard than planned!).

In the sections below, the author will discuss a number of issues connected with the ID process. Questions such as the following will be addressed:

1. What is the instructional design (ID) process?
2. Does the ID process differ from what instructors already do in preparation for a curriculum, a course, or a lesson?
3. How can instructors improve their course preparation and delivery by using the ID process?

1.6.1 What is the instructional design (ID) process

There are over 50 instructional design models (Gustafson & Branch, 1997), but many of them share several key attributes including:

1. ID models stress the importance of knowing the learners for whom the training is being developed (learner analysis).
2. Strong emphasis on carefully developing and using instructional objectives[1].
3. How learners learn based on learning proven concepts, theories, and techniques (instructional strategies).
4. How do you determine the goodness of the instructional program (evaluation or assessment)?
5. Emphasis is placed on the learner rather than the content.

[1] *Instructional objectives and learning objectives are used interchangeably in many references, but in this text, the author has maintained use of instructional objectives.*

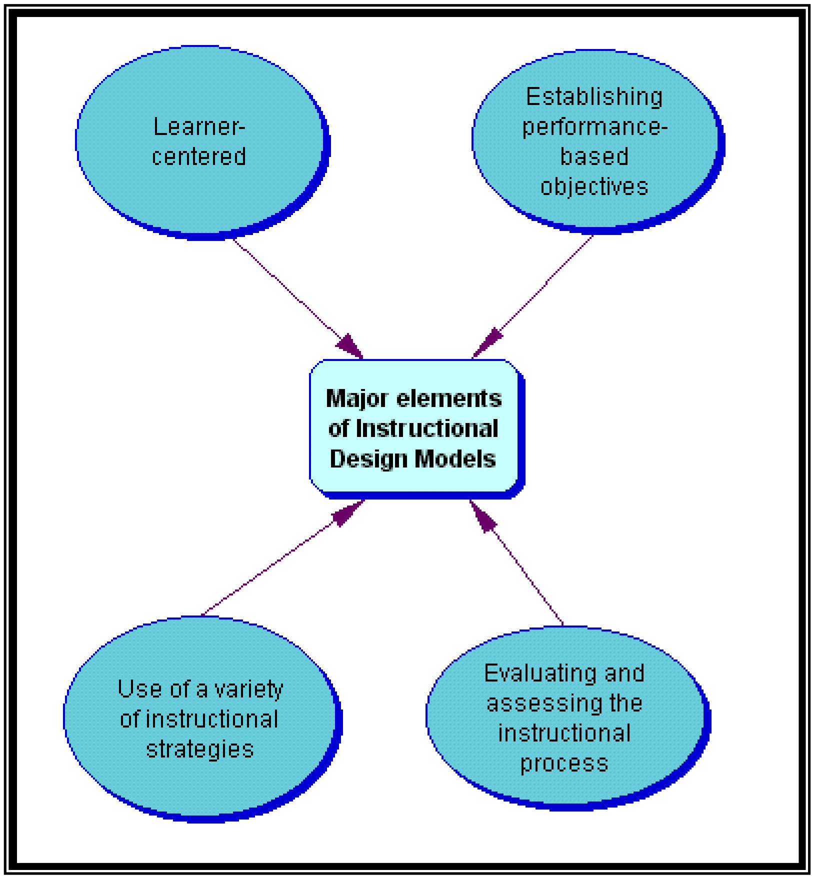

Figure 1.2. Basic elements of the instructional design model (taken after Kemp, 1998).

These fundamental attributes are shown in Figure 1.2 and further described in Table 1.2. Specific examples of how these principles can be applied to your classroom setting will be given in the sections below and in Chapter 2.

Model Attribute	Description
Learner-centered	• *The learner should be at the center of the process, not the instructor* • *One should ask, "What does the learner need to know or demonstrate following a lesson, a block of lessons, the course," rather than "what content should be covered."* • *What do learners already know about the subject prior to the instructional unit? Identify learner characteristics during course planning.* • *Use learner's prior knowledge and skills as part of the instructional delivery (see Chapter 2 for examples).*
What learners learn	• *What are the purpose and goals of the instructional program?* • *Base the instructional unit on a combination of knowledge and performance by the learner: "What do you want the leaner to be able to do following the course?"* • *What tasks are required to solve the instructional problem?* • *Use instructional objectives as a basis for planning, implementation (delivery of instruction—see next attribute), and assessment.*
Presentation of materials	• *What is the best sequence of delivery?* • *What is the most effective way to design the instructional units?* • *How do we deliver the instruction: lecture, small group activities (cooperative learning), exploratory learning, or self-paced learning?*
Evaluation of instructional program	• *What evaluation processes can be used during the development of instruction?* • *How do we assess the effectiveness and efficiency of the instruction following the completion of the course?* • *Are there ways we can assess the instruction as the course progresses?*

Table 1.2 Description of the major attributes of the instructional design model

1.6.2 Using the instructional design process

As a means to illustrate the basic ID process, I have combined two ID models designed to meet the needs of teachers and instructors in academic situations. These ID models could easily be used by instructors at National Training Centers and by the training officer of most NMHSs as refresher texts or to provide new instructor orientation and on-station references. The Kemp Model (Kemp et al., 1998) and the Diamond Model (Diamond 1997) are used to develop the sections below. Generally, the writer has weighted discussion around the Kemp model, but key factors of Diamond are also integrated. I will describe the steps found in these models in the sections below.

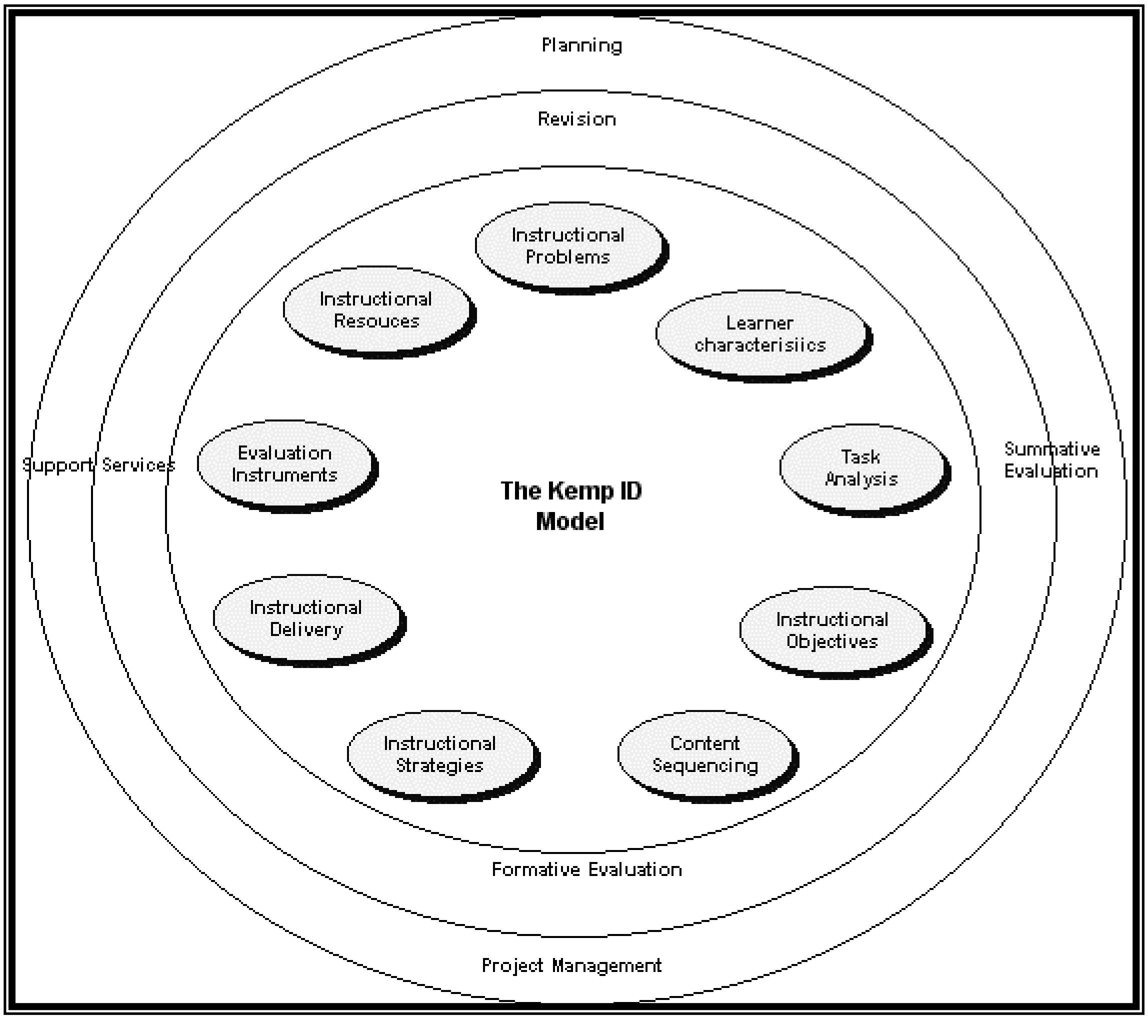

Figure 1.3. Steps in the Kemp instructional design model (see Kemp, 1998 for details).

Looking at Figure 1.3, we see the following features of Kemp's ID model (see p. 6 of the text):

1. The nine steps of the model are in an oval shape (the author's rendition does not do justice to the original diagram—see the text for the full affect) suggesting that one does not have to start with "instructional problems" located at the twelve o'clock position. Instructors can proceed along the ID process in whatever fashion they deem necessary.
2. Lines connecting each of the nine steps are missing, suggesting that one does not have to follow a linear, stepwise process.

3. The oval orientation of the process lends itself to the way teachers develop instruction. For example, teachers think in terms of what learners need, the content, and how to deliver it in the classroom. One may have in mind a few key objectives, but once you're in the classroom delivering content, you may think of other objectives or ways to improve the ones currently in use. Using Kemp's model, you can move back and forth along the process.

In this chapter, the writer describes the first four steps while in Chapter 2, he discusses "content sequencing," instructional strategies, and instructional delivery. Let us now take a closer look at the Kemp and Diamond models.

1.6.2.1 Instructional Problems

From the author's experience, one of the key benefits of using the ID model is that it provides decision makers, trainers, and instructors with guidance in determining the exact nature of potential training problems. Managers and instructors should ask questions such as:

- What are the needs of the organization?
- Is instruction really needed?
- Are training and instruction treating the symptoms rather than the true cause of problem?
- Are there other issues that need to be explored before resources are devoted to developing training programs that will not prove beneficial?

The purpose of a "needs assessment" is to analyze problems that are brought to the training institution. Another application for a needs assessment might be for the training officer of a NHMS. For example, the training officer could use a needs assessment to research further what are the causes of problems that surface within the organization. She/he could better determine if the true problem was training or some other issue.

Training institutions such as those of the RMTCs and NHMSs will not likely be in a position to conduct complete needs assessments. Since their mission is to develop and provide training, they will have a propensity to do just that. However, it would be valuable for readers to review the process of needs assessment so that one gains a valuable perspective on how to frame stated problems. Kemp's book provides an excellent description on how to conduct a needs assessment, if the reader is interested in pursuing this topic.

A more practical process for training organizations to conduct is "goal analysis." Whereas the instructor uses a needs assessment to determine the problem, you conduct a goal analysis on needs (if the need requires instruction to solve it) to develop the goals for the training program. At a RMTC, an instructor team could conduct a goal analysis using the six steps described in Kemp's text (see pp. 28-30). We next investigate how to assess information about our learners.

1.6.2.2 Learner characteristics

We've already touched on the learner analysis earlier, but we'll recap the major points on this step which are:

1. Entry level skills and knowledge should be determined prior to instructional program development. As instructors, we often assume students come to class well acquainted with prerequisite knowledge and skills. Students may or may not readily admit they do not understand these concepts in class. It might be useful for the instructor to survey student's prior knowledge and skills during the initial part of the course. This can be in the form of a formal prerequisite test or survey or simply asking a series of questions in an informal setting.
2. Another important process to consider is student learning styles. This is very often overlooked in traditional learning institutions, but can impact the overall learning process considerably. According to Diamond (1997), the lecture continues to be the

most widely used teaching method. On the other hand, many students are not audio learners and may require a high level of visual material or interactions with others to profit the most from the instruction. As pointed out by Kemp et al. (1998), the problem is to determine each student's learning style. The best solution may be a mix of teaching methods and perhaps lean more toward the visual and interactive styles and place less emphasis on the lecture (this topic will be addressed in much more detail in Chapter 2).

1.6.2.3 Task analysis

The next step in the ID process is to consider the tasks that learners are asked to learn—this falls under conducting a "task analysis". This is one of the most important steps as it provides input for developing learning objectives which drive the rest of instructional design.

Given ample resources, instructors could develop a detailed task analysis. However, most institutions do not allow instructors the required time. Given these constraints, two useful analyses can be developed by most instructors, the results of which will help in developing instructional objectives. Topic and procedural analyses will be described next; the reader is encouraged to read about these processes in Kemp's text for additional detail. In Chapter 2, the writer will provide examples of these analyses using the RAI African Satellite Meteorology, Education and Training (ASMET) project in which four instructors from RMTCs developed multimedia programs using many of the ID steps described here. The author, in his experiences in the classroom, will be the first to admit that it is very difficult to complete either analysis in detail. However, it is important to consider the process and even if the reader mentally considers the key steps, he/she will have a better idea of what they want the students to be able to do following instruction.

1.6.2.3.1 *Topic analysis*

A "topic analysis" provides two types of information. First, the instructor outlines the lesson in terms of the content. Secondly, you describe the structure of the content. Here, each element of the content can be classified into one of six structures as:

- Facts—arbitrary (in terms of the context in which used) association between two things. Definitions, names, and descriptions of objects and events are all facts. Facts are the building blocks of any content or subject area. Obviously, the field of meteorology has thousands of facts; examples include: the standard surface pressure is 1013 MB; one knot equals 1.15 statute miles/hour; the tropics encompass the region within 25 degrees N and S of the equator (a bit arbitrary).
- Concepts—categories of related or similar ideas, events, or objects. For example, cloud formation is a concept that describes an object formed by a process similar to that of rising air lifted beyond its condensation level.
- Principles or rules—describes the relationship between two or more concepts. Examples might include density is related to mass and unit volume; pressure is related to temperature; and wind is related to Coriolis force, the pressure gradient force, and friction.
- Procedures—an orderly sequence of steps that a person must follow to complete the task correctly. If we want the learner to measure the dewpoint temperature using a sling psychrometer, one must follow a prescribed set of steps to obtain the correct answer.
- Interpersonal skills—procedures, suggestions, hints as to how to interact with people.
- Attitudes—"predisposition (s) to behavior."

(Interpersonal skills and attitudes will not be discussed further).

1.6.2.3.2 *Procedural analysis*

A procedural analysis is used to outline the steps of an observable procedure. Kemp et al. (1998) describe three steps to this analysis technique:

1. What does the learner do?
2. What does the learner need to know to do this step?
3. What cues inform the learner that there is a problem, the step is done, or a different step is needed?

In addition to a written description of the steps, flowcharts are often used to visualize the procedures. There are many applications of this technique in weather forecasting that come under names such as “decision trees”, “rules of thumb”, and the like.

1.6.2.4 Instructional objectives

The next step in the ID process is the development of instructional objectives. I believe that a well-constructed instructional objective is one of the key elements to improving the delivery of instruction and improved learning opportunity for students. I fully recognize the controversy surrounding the use of learning objectives by teachers and students. We’ll describe Kemp and Diamond’s approach to learning objectives and some of controversy issues existing in the education community. In Chapter 2, specific examples of how objectives are used in the delivery of instruction will be presented and explained further.

1.6.2.4.1 *Reasons for using instructional objectives*

According to Diamond (1997 and Kemp et al. (1998) there are several reasons to integrate carefully worded and specific instructional objectives into the course and lesson level, including the following:

- Provides guidance for the instructor to design the instructional unit, including the selection and organization of activities and resources (see Chapter 2 for details).
- Provides guidance for the instructor to develop assessment instruments.
- Helps guide the learner to know what is important.
- Provides for consistency between the goals of the course, the content, and evaluation.
- Changes the emphasis from what the instructor must cover to what a student should be able to accomplish as it relates to the course and lessons.
- Enhances communications among all parties of the institution including leadership, department leaders, other instructors, and students.
- Encourages self-evaluation for students because they know what is important.
- Student anxiety is reduced and learning is more efficient because students have direction and they know the instructional priorities.
- A logical course structure is communicated to students and others.

1.6.2.4.2 *Writing instructional objectives*

Instructional objectives are usually described for three domains: cognitive, psychomotor, and affective. We’ll focus on cognitive and psychomotor.

The cognitive domain addresses many tasks we perform in the geo-sciences that are related to knowledge and information, analysis, data, predicting, and establishing relationships between different concepts. A widely used classification of the cognitive domain (taxonomy) developed by Bloom (1956) shows two basic categories:

- simple recall of information and,
- intellectual activities.

Simple recall is what Bloom calls basic knowledge, while intellectual activities are divided further into five increasingly more intellectual levels of comprehension, application, analysis, syntheses, and evaluation. Table 1.3 shows examples of this classification applied to a typical lesson in tropical meteorology.

Level of Bloom's Taxonomy	**Course: Introduction to Meteorology** **Topic: Global Circulation**
Knowledge: Recall of specific information	*Define pressure gradient force (PGF), Coriolis force, and friction.*
Comprehension: Lowest level of understanding	*Describe the relationship between PGF, Coriolis force, and friction.*
Application: Application of a rule or procedure	*If you have a balance between PGF and Coriolis force and then add friction, what is the resultant vector diagram and affect upon the wind direction and speed?*
Analysis: Breaks an idea into component parts & describes the relationships	*Given cyclonic flow in the southern hemisphere, analyze the components of the wind around the cyclonic flow pattern.*
Synthesis: Puts the parts together to form a new whole	*Develop a general surface pressure pattern that would result from a rotating earth.*
Evaluation: Makes judgements about materials & methods	*Given selected geographical regions around the globe, formulate a climatology of that region based on the influence that the general circulation might have.*

Table 1.3. Examples of the use of Bloom's taxonomy.

Traditionally, instructional objectives have been written using a behavioral format. Teachers have resisted the use of learning objectives, in part because they were presented in behavior terms ((Diamond, 1997). Kemp suggests using cognitive objectives as an alternative to behavior objectives. There are two steps to writing a cognitive objective. First, the teacher writes a general instructional objective stated in broad terms using a learning domain such as apply, understand, or calculate. The second step is to add one or more specific performance statements that can be used to measure a student's mastery of the subject. An example of a cognitive objective used to teach "The Basic Forces that Cause Wind" might be as following:

Describe the forces that create wind.

1. Review definitions of air pressure and global temperature differences.
2. Define wind and its role in the global circulation.
3. Define the three forces that create wind.
4. Describe the pressure gradient force.
5. Describe Coriolis force

6. Describe how friction affects wind.
7. Describe how the three forces act together (conceptually and mathematically).
8. Construct vector diagrams to show the relationship between the three forces.
9. Using a surface chart, evaluate the contribution of each of the forces that is reflected in the observed wind pattern on the chart.

There are two primary parts to each objective. The first part is an action verb. The action verb used is associated with the levels of learning defined in Bloom's taxonomy. Table 1.4 shows a number of examples that can be used in the sciences. The second element of an objective is the subject of the objective. These two parts of an objective will define what the instructor wishes the student to be able to do at the end of the instructional unit. There are optional elements of objectives contained in Kemp's text; the reader is advised to review this text for more detail, but the above process can get you started.

After the objectives are written, the instructor links them with instructional strategies and assessment instruments such as tests, homework, and laboratory exercises. Kemp et al. (1998) describe a planning technique to link each objective with one or more structures of the content (see previous section on Task Analysis) and a performance statement. Table 1.5 shows an example of this technique. We will see how this can be used in delivering instruction in Chapter 2.

Knowledge **Recall of information**		**Comprehension** **Interpret information in one's own words**		**Application** **Use knowledge**	
Name Arrange Define	List Label Order	Classify Describe Discuss Identify Locate	Report Review Select Translate	Apply Demonstrate Illustrate	Interpret Prepare Practice Solve
Analysis **Show relationships among the parts**		**Synthesis** **Bring together parts of knowledge to form a whole & build relationships for new situations**		**Evaluation** **Make judgements on basis of given criteria**	
Analyze Calculate Compare Contrast Diagram	Differentiate Discriminate Distinguish Experiment Test	Arrange Collect Construct Create Design	Formulate Organize Plan Prepare Synthesize Write	Argue Assess Compare Defend Estimate	Evaluate Predict Select Support

Table 1.4. Action verbs that can be used to write instructional objectives. Table taken Kemp, et al. (1998). See p. 77 for details.

	Performance	
Content	**Recall**	**Application**
Fact		
Concept		
Principle or rule		
Procedure		

Table 1.5. A technique to link the structure of a learning objective with a performance statement that can be used to deliver instruction.

1.6.2.4.3 *Difficulties in using instructional objectives*

The author will be the first to admit that using learning objectives at the course, block, or lesson level is extremely difficult. We often teach the way we were taught which did not include (for most of us) the use of objectives. It's much easier to see the value of using objectives than it is to apply them to our instructional planning and implementation process. It's clear also that strong resistance exists against using objectives in the first place. Some reasons NOT to use objectives might be:

- It reduces the amount of creativity by the instructor.
- It suggests students be engaged in TRAINING not LEARNING.
- It's too structured.
- We can't be that exact with our intentions.
- It spoon-feeds the students---they're supposed to think on their own.

The author's suggestion is to consider the advantages of using objectives (see section 1.6.2.4.1 for some positive reasons) and test the idea, as indicated in the block below. In Chapter 2: Training Delivery, we will see how the objectives can be linked to the classroom more directly.

FROM HERE TO THE CLASSROOM: *There are plenty of reasons to use objectives, but it's difficult to implement them for the first time. Test using them in small steps. Rather than write objectives for an entire course or block of instruction, try using objectives for one lesson or a series of lessons that are linked closely together. Write objectives that answer the question, "What do I want the students to be able to do after they finish this lesson or series of lessons. Once you feel comfortable with the objectives, try introducing them to the students to get their reaction. Ask them what they think about using objectives as a learning technique*

1.6.2.5 Content sequencing, instructional strategies, designing the message, and instructional delivery (including selection of media)

The next three steps of our ID model focus on developing and delivering instruction. These steps are treated Chapter 2.

This concludes the overview of the instructional design process. For most readers, the very idea of instructional design is new. The experienced instructor or teacher might be saying right now, "I already use these techniques and ideas—I've been teaching for over 20 years, so what's so new about this stuff?" In part, this statement is correct. But, that is only part of the answer. In the last section of this chapter, we'll briefly compare and contrast what teachers say about the ID process and some ways that it can enhance your planning and implementation process.

1.7 ID models and teachers---is there a conflict?

In the past 10 years, the author has witnessed resistance from teachers to use the instructional design model. At first, I attributed the resistance to people not wanting to change or accept new ideas. However, my classroom experience suggests that time does not permit one to follow the ID process completely. I think more in terms of “how will I present content and include the students in the learning process, and does the classroom or computer network support my delivery?” These notions are supported by the research done by Earle, (1997) and Moallen & Earle, (1998)—teachers think of instructional development in a different way. They imagine the classroom setting first, then consider how the content can be structured into that environment where there is continuous dialogue and interaction with students. Branch & Fitzgerald (1998) sum the situation up nicely by concluding that teachers focus more on the implementation and evaluation of instruction while instructional designers concentrate on the more complete ID process.

Instructors can improve their instructional development and delivery by considering the ID process from the whole image rather than from a few brush strokes. Hopefully, instructors can gain some of this from this chapter and references in this text. In addition, principals may consider organizing workshops or seminars led by experts in the ID process and ways that can help instructors improve their instructional development and delivery. It is important, however, for these individuals to recognize how teachers think and develop instruction for the classroom and make every attempt to find ways to synthesize the two processes.

In the future when international training institutes offer distance education programs, instructors may have to consider a different process for developing instruction. Effective distance learning programs are more complex and require a different approach for design, development, delivery, and evaluation—the ID process will provide a suitable framework around which to work.

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Chapter 2: Training Delivery

2 Introduction

In Chapter 1, we discussed the Kemp (Kemp, Morrison, & Ross, 1998) and Diamond (Diamond, 1997) instructional design models that outlined steps that can be used to design a course, re-design an existing one, or used as a guide in developing lessons. We saw that it is important that you use a variety of information and data to determine the needs of the course and the importance of knowing the learners for whom the course is designed. We also explored the use of instructional objectives that are used to link "what the instructor wants the learner to do, feel, or demonstrate" following the learning experience in the classroom or laboratory. In this chapter, we'll complete the third important link to objectives and assessment—steps to design and deliver instruction to the learner in the classroom or other venues. First, we will review what will be covered in this chapter.

2.1 Purpose of the chapter

The purpose of this chapter is to provide instructors with basic knowledge and skills in developing and delivering lessons using modern learning concepts and principles.

2.2 Chapter goal and objectives

2.2.1 Chapter goal

The goal of this chapter is to familiarize the reader with instructional strategies that are derived from learning theory. With key instructional strategies available, instructors can determine how to deliver effective lessons.

2.2.2 Learning objectives

At the completion of this chapter, the reader will have accomplished the following:

- Compare and contrast traditional and modern learning principles and theories
- Select instructional strategies appropriate to content, learners, and instructor
- Determine the most effective method for sequencing lessons
- Describe various ways to produce instructional materials
- Identify and select appropriate delivery methods

2.3 Recall of the instructional design process

Where are we in the instructional design process?

Let us start this chapter where we left off in Chapter 1 using the Kemp instructional design model. In Figure 2.1, we show the Kemp ID model and highlight the three steps[1] that are included in our discussion on delivering lessons.

[1] *In Kemp's original model, the authors included an additional step between Instructional Strategies and Instructional Delivery termed "Designing the Message". This step will not be discussed specifically in this text.*

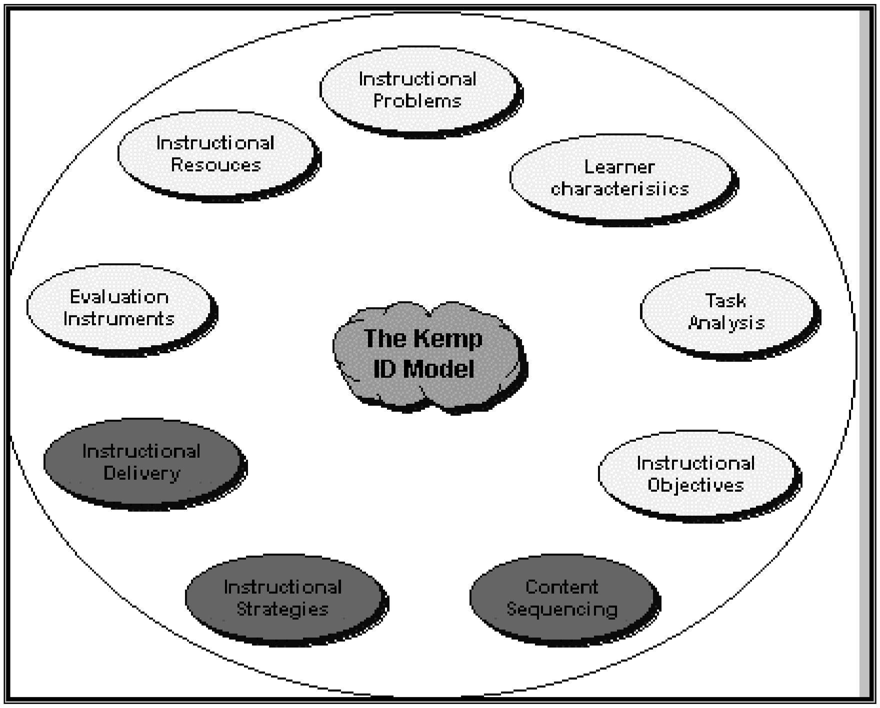

Figure 2.1 The Kemp Instructional Design Model.

The steps of the model that we will cover in this chapter are:

- Content sequencing
- Instructional strategies, and
- Instructional delivery

We will use these three steps as a means to discuss how the instructor can design and deliver lessons. As in Chapter 1, the writer takes the best of the Kemp and Diamond instructional models to develop ways to move from instructional objectives to effective instructional materials to be delivered to the classroom. These three steps, as shown in Figure 2.1, have been restructured to account for several important steps described in the Diamond model. Figure 2.2 shows the steps that will be discussed in the sections below that take into account the best of the Kemp and Diamond instructional models. Before describing these processes, let us digress for a moment to review some of the key points about learning concepts and principles. As we consider our traditional instructional methods, this brief review will provide a background for us to consider other design and delivery techniques.

2.4 Learning principles

For simplicity, we can divide learning principles into two major categories. The first one is behaviorism, a method of learning that most of us experienced in school. Included in behaviorism are other traditional learning principles including repetition and reinforcement. In contrast to behaviorism is the cognitive learning theory where learning moves away from solely stimulus-response setting to an environment where learners build new knowledge from their existing knowledge and experiences, from real-world experiences, and the classroom. In the sections below, we'll briefly describe these two learning principles.

2.4.1 Traditional learning theory

For teachers and students working in a behaviorist learning environment (this is not to suggest that these examples represent typical instructional techniques at national training centers, rather these examples are generic situations drawn from the literature and witnessed by the author in his instructional settings), they might experience or practice any one of the following practices:

- Lecturing would be the dominant teaching method (not necessarily—see below)
- Learners would be considered partially filled glasses that are “filled” with knowledge and skills from the teacher
- Knowledge would be judged by the response to a stimulus
- Dialogue in the classroom would be minimal since students would be more interested in taking notes from the knowledge source, the teacher, rather than comparing their experiences with other students or the teacher
- Knowledge and skills are presented in the abstract rather than in real-world settings.

2.4.2 Time-tested methods: repetition, reinforcement, and stimulus-response

A number of time-tested learning principles remain valid even though they may have derived from behaviorism. According to Diamond (1997) and Watson (1961), some of these time-tested learning principles include:

- Behaviors that are rewarded (reinforced) are more likely to recur.
- Sheer repetition without indications of improvement or any kind of reinforcement is a poor way to attempt to learn
- Threat and punishment have variable and uncertain effects upon learning.
- For reinforcement to be effective, it must follow immediately the behavior desired.
- The best reinforcements are those that one gives oneself
- Forgetting proceeds rapidly at first then more slowly; recall shortly after learning reduces the amount forgotten (author’s note: but is this effective learning?)

Our intention in the brief review of behaviorism is not intended to criticize the principles, but to show the foundation of how most of us learned and the way most instructors continue to teach. Many of the basic principles remain valid, but another approach to learning, and one that the author strongly endorses, is the application of the principles of cognitive learning. These principles will be discussed.

2.4.3 Cognitive principles and theories

Quite different to our traditional learning principles, the writer now introduces cognitive learning ideas (another term often used with cognitive learning is *constructivism*), which has become a dominant voice in the way teachers carry out instruction. It’s important to keep in mind that advocates of cognitive learning have not jettisoned many of the time-tested learning principles; they simply see learning as more than just a lecture and believe that learning can be more effective and efficient with some changes.

2.4.4 Applications of cognitive learning in the classroom

The best way to illustrate the differences between traditional learning methods and cognitive learning is to show how they might be applied in the classroom. In Table 2.1, I have listed a number of situations where the learner and instructor might observe the differences between a traditional and cognitive learning environment. Again, these illustrations are not intended to represent situations in any particular training institutions, but are drawn from the literature and the author's experiences (some of which he has practiced). In the next two columns, I show how we would observe activities in a traditional behavior environment and in a cognitive learning environment.

If you compared instructional activities	**You would observe this in a traditional learning environment…**	**And this in a cognitive learning environment…**
The instructor-student relationship is…	Students would be passive while the instructor did most of the action, i.e. an instructor-centered environment	A student-centered environment where students actively participated in learning
Learning is conducted by…	Students listening to the instructor- led activities	Learning groups, cooperative/collaborative learning activities, exploratory learning, and other student-based activities.
What instructional tools are used…	Mostly the lecture and laboratory sessions	A wide variety of instructional media including multimedia, the WWW, library searches for content, and others
Learning would focus on…	A content-based curriculum	Instruction focusing on performance and real-world environments
The perspectives gained by students would be…	Mostly that of the teacher	Multiple perspectives provided by teachers, guest speakers, and those gained by exploring on their own to build interpretations of the material
Who does most of the work in preparing for instruction?	Generally, the teacher does most, if not all, of the work in preparation of lectures and laboratory.	Students not only prepare for class, they actively build new knowledge and skills in the classroom by conducting their own learning.

Table 2.1. A comparison of the traditional and cognitive learning environments

The reader can grasp the essence of cognitive learning concepts by drawing on summaries from two key writers of the field. Honebein (1996) offers seven goals that one should strive to reach in a cognitive learning environment (the author does not necessarily endorse these goals; these will be discussed in subsequent sections of this chapter in terms of classroom application and experiences). These are:

1. Provide experience with the knowledge construction process by allowing students to take responsibility for determining the topics or subtopics in a domain they pursue.
2. Provide for multiple perspectives on the content because the real world seldom provides only one perspective.
3. Develop instruction in a context of real-world environments so students see relevance in the content.
4. Encourage ownership of the learning process by students not just by the instructor.
5. Ensure that learning is a social experience by group activities and team building processes.
6. Ensure that the learning environment contains multiple modes of representation including oral, written, video, WWW, sound, and computer-based learning.
7. Encourage self-awareness of the knowledge construction process by students.

Finally, I would like to offer the reader a definition of a cognitive or constructivist learning environment by a colleague who has helped design computer-aided learning (CAL) modules for operational forecasters and conducted workshops at the CALMET conferences. Wilson (1996) (see p. 5) defines a constructivist learning environment by:

> A place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities.

Using this brief review of learning principles as a foundation, let us now discuss ways that the reader's teaching and learning techniques might be improved by following the steps in preparing and delivering lessons in the classroom.

2.5 Planning the instructional sequence

In the sections below, we complete four key steps in the learning process. Figure 2.2 shows the four steps (design the sequence, delivery format, instructional strategies, and process options) that will guide you in preparing the instructional program for delivery in the classroom. Our inputs to these processes are the instructional objectives, the task analysis that was discussed in Chapter 1 (we will use Table 1.5 for further lesson development), and results of learning theory as discussed above. As you can see from Figure 2.2, the output from this process is a set of materials ready for delivery to your students. After considering the four steps, you need to consider the media that might be used in the delivery. For the purposes of this text, we will concern ourselves mainly with educational technologies. As we will discuss in the section on educational technologies, we want to make sure technologies are employed to solve a specific teaching or learning problem rather than simply using them as new gadgets. Figure 2.2 is a composite of the steps used in the Kemp and Diamond ID models, tempered by the author's experiences. Let us now examine each of these steps.

FROM HERE TO THE CLASSROOM: *THIS ALL SOUNDS GOOD, BUT HOW DO I APPLY IT? Let me share some of my experiences…My advise to you is to take very small steps rather than attempt to apply all that follows in one giant step. For example, consider the "best sequence" section first. Use your existing lecture or prepare a lecture as you would normally. For Step 1, consider doing this. First, design an optimal sequence to your lecture that might include other activities using some of the* *suggestions. Second, include in your lecture one of the pre-instructional techniques. After applying these methods for a 2 or 3 times, assess how it works, refine the methods, and then advance to some of the suggested instructional strategies (other than the lecture or whatever methods you are comfortable with).*

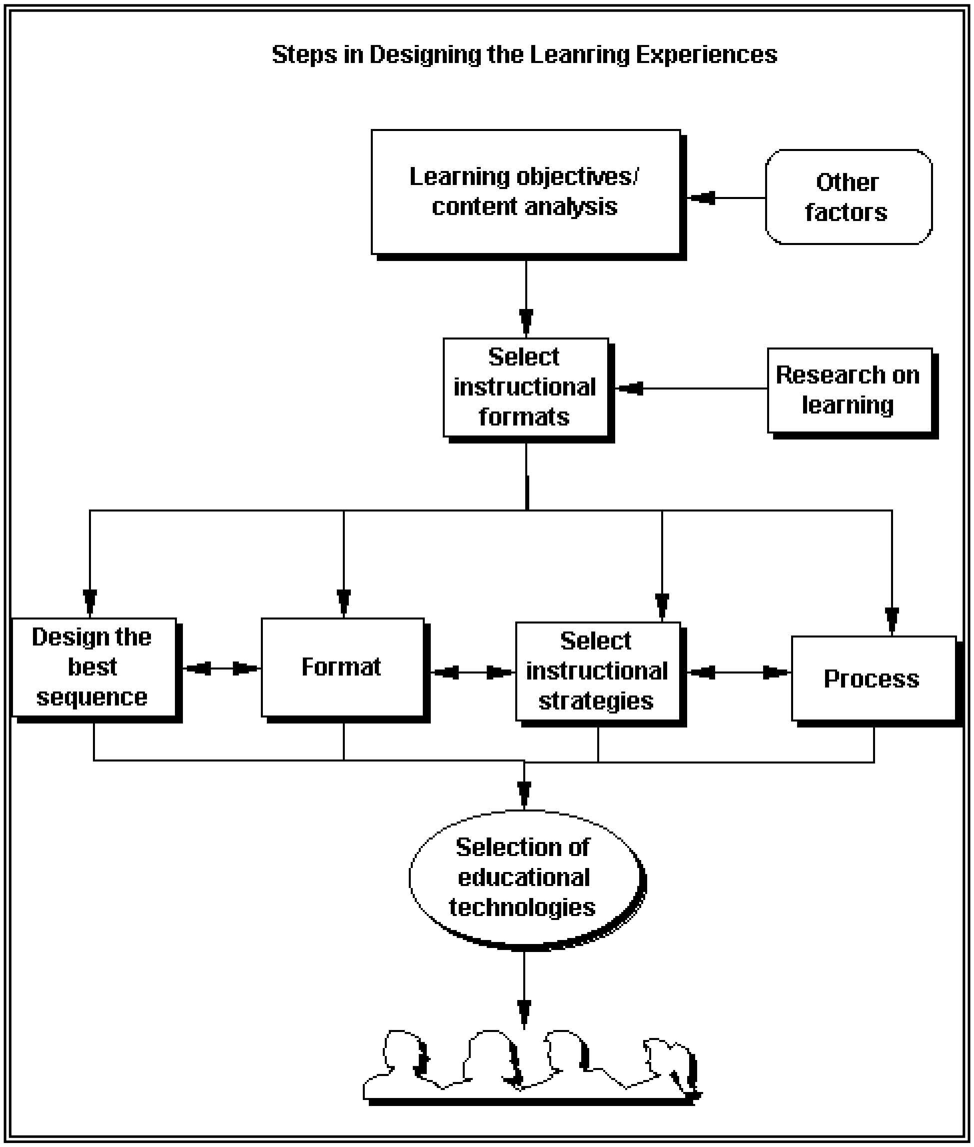

Figure 2.2 Steps in planning lessons, courses, or instructional materials

2.5.1 Designing the best sequence

At this stage, we're ready to design and plan how we want to deliver the lessons to our learners. There are two activities that will help you design your lesson: an effective sequence and pre-instructional techniques.

2.5.1.1 The optimal sequence

According to (Kemp et al., 1998), "Sequencing is the efficient ordering of content in such a way as to help the learner achieve the objectives." (see p. 91). I will use two examples of how sequencing has been accomplished: one from COMETs© *Marine Meteorology Series* and another from my own experiences teaching a course in higher education. Let's first look at the example from the marine meteorology project.

Marine Meteorology is a series of lessons (one might use the term module that would include a number of short lessons) on sea state forecasting, visibility at sea, and ship structural icing. We'll focus on the series of lessons on sea state forecasting. The sequence that the design team[2] selected went something like the following:

1. Assess how good and poor forecasts of sea state impacted end users: aircraft carrier captains, commercial fishermen, and recreational boaters.
2. Compare and contrast the land and marine boundary layers.
3. Define wind characteristics and determine how to measure them in the marine environment.
4. Calculate a wind field where the forecaster wishes to develop a sea-state forecast.
5. Define the factors that contribute to wind-generated waves and swell.
6. Describe techniques for forecasting wind waves and swell.
7. Provide case studies to illustrate how a novice marine forecaster would apply the forecast techniques in a real-world situation.

What sequencing techniques were used in this example? We can distinguish several sequencing techniques from the list above. First, the design team wanted *to gain the attention* of the learner by showing how his future performance might affect the end user. Second, the design team wanted to bring *relevance* of the material to the user—thus the use of real people telling the learner (forecasters) what happens when marine forecasts go bad (or how appreciative they are when the forecasts work out as published). Third, the design team sequenced the content in *prerequisite order*, i.e. one has to understand how the marine boundary layer winds are computerized before you can calculate the wind waves or swells. The design team also wanted the learner to be able to evaluate his performance so they designed two case studies into the CAL program.

Let us now look at a classroom example. Two lessons on airmasses, the wave cyclone, and fronts were developed for non-majors of meteorology. Our textbook used the order shown above, but this author decided to change the order to the following:

1. Airmasses
2. Fronts
3. Upper level flow
4. The Wave cyclone

Students in this course are non-meteorology majors and most of them will attend a one-year pilot training program following graduation from the four-year university. My primary reasoning for discussing fronts before discussing the connection of fronts to the upper levels and the wave cyclone centered on *learner familiarity* with fronts and associated clouds. Rather than lecturing on the cold, warm, and occluded fronts, I used a videotape that showed what a pilot might observe on flying through these features at a certain altitude in terms of clouds, weather, and hazards to their flight operations. In addition to being very relevant (and hopefully motivating) to future pilots, I also used what was already familiar to most of the students—flying and clouds (student teams had developed presentations on various types of clouds from a previous lesson). By starting

[2] *The design team consisted of an instructional designer, three part-time subject matter experts (SME), and other support team members.*

with familiar concepts and processes, I was better able to develop the remainder of the lessons on less familiar or new facts, concepts, and processes.

These programs used several sequencing techniques described by (Kemp et al., 1998 - see Chapter 6). In this chapter, the authors point toward two main categories of sequencing techniques: learning-related and content-related. Table 2.2 shows additional information about the learning-related technique.

Phenomenon	**Example/Principle**
Identifiable prerequisite	• Teach a skill required to perform another skill first.
Familiarity	• Start with concepts with which the learners are most familiar, then introduce less familiar ones. • Focus on the trade wind belt before studying the westerlies in great depth.
Difficulty	• Begin with less difficult then move toward increasing difficult concepts and processes.
Interest	• Center on things your learners are highly interested in before studying those of less interest.

Table 2.2. Learner-related sequencing. After Kemp, et al. 1998—see pp. 92-93.

Another general guideline that the instructor might use in developing a sequence is the one provided by (Gagné, Briggs, & Wager, 1992). Table 2.3 describes Gagné's *events of instruction.*

Instructional event
1. Gain the attention of the learner 2. Review lesson objectives or what you want the student to do following the lesson. 3. Stimulate recall of pre-requisite content. 4. Present a stimulus for the learner 5. Provide learning guidance. 6. Prompt the learner for performance of the concept, process, or procedure. 7. Provide feedback about performance. 8. Assess performance 9. Enhance retention of the content.

Table 2.3. Events of instruction. After Gagné, 1992. See p. 190.

There are a few additional techniques that the instructor might apply before the learner and instructor move into the major portion of the learning program—these are called pre-instructional steps and are discussed briefly next.

2.5.2 Pre-instructional techniques—the format

The primary purpose of the pre-instructional segment of the lesson is to gain the attention of the learner, insure that the learner is prepared for the upcoming lesson, provide links between previously studied materials and the new content, and provide an advance organizer for the new lesson. Some pre-instructional techniques will now be illustrated using a lesson on tropical cyclones given to non-degree students.

In this initial segment of a 50-minute lesson on tropical cyclones, four elements that are shown in Table 2.4 are used. A brief explanation of these elements and examples of them are shown below.

The instructor might consider giving students a short pre-test (listed last in Table 2.4) which would be due prior to the lesson on tropical cyclones. This will insure that each student completes the required reading assignment, coming to class with some prior knowledge, and if group activities are used, then each student should be able to participate. The author has used this technique many times with excellent success, especially when it is used in conjunction with collaborative learning techniques.

Gaining the attention of the learner is an important step in lesson planning. Students usually have many things on their mind when they show up for class. It's important to take a few minutes to provide them a new focus on the lesson and how it relates to them. In this lesson, two methods will be used to draw attention to the new lesson. The first will be a series of still images that show damage by tropical cyclones and in the second, a movie shows a strong typhoon moving onshore along the Chinese coast. These sequences will be followed by asking a number of questions regarding tropical cyclones around the world and how information the students study in this lesson will help them following graduation. The questions combine to form the attention gaining step as well as an overview to the lesson. A few examples of questions that might be asked are shown in Table 2.4. Of course, the instructor has to focus the questions on the specific learners and the topic.

Pre-instructional technique	**Explanation/Example**
1. Gain the attention of the learner	• Satellite loops showing tropical cyclones moving inland • Damage from tropical cyclones • News articles showing how tropical cyclones affect people

2. Overview of lesson	• Questions that the learner can answer following instruction
	• Examples for the tropical cyclone lesson
	    • How will tropical cyclones affect the Spratly Islands?
	    • How do typhoons differ from hurricanes?
	    • Do tropical cyclones occur in the southern hemisphere? When? How strong?

3. Advance organizers	• Concept map showing how previously studied content fits with the new lesson • Concept map showing the content of the new lesson
4. Pretest	• As part of homework from the previous lesson, students answer a few questions to ensure that the reading assignment was completed and they are ready for the lesson.

Table 2.4. Pre-instructional techniques and examples used in the classroom.

The next step in the pre-instructional phase of the lesson is the use of advance organizers. An advance organizer is used to clarify content from a conceptual perspective, used with above average learners, and can be displayed using a variety of forms (Kemp et al., 1998). For the introductory lesson, the author decided to use a visual advance organizer to show how some of the concepts and processes covered in previous lessons are connected to tropical cyclones. This helps the learner recall content covered earlier and shows how it fits together. Another advance organizer is used to show the new content that will be covered in the lesson and how it linked to the tropical cyclone. The instructor can use either text as a format for these advanced organizers or you can use a visual format such as a concept map (Weisenberg, 1997).

One of the most effective visual organizers is the concept map. A concept map is a spatial learning strategy that provides “a way of graphically displaying concepts and relationships between them or among concepts” (West, Farmer, & Wolfe, 1991, p. 93). In a general way, a learner constructs a concept map by identifying concepts, facts, and processes and the relationships between them from a reading, plotting them on paper or a computer program (see below) and naming the relationships.

Instructors have at least four ways that they can be employed in the learning environment. First, learners can use concept mapping to organize and better understand the relationship between facts, concepts, and processes. Second, instructors can use mapping techniques as part of their lecture to visually illustrate the connections between concepts and processes. Third, concept maps can be used as an assessment instrument. It is especially important in the sciences for students to understand and demonstrate the relationships between concepts and processes. Finally, instructors can use concept maps as a table of contents or visual organizer of a body of knowledge to be presented to students. A well-organized concept map provides an excellent roadmap for students to see where they are heading.

It will be helpful at this point to show how concept maps can be used in the classroom. Figure 2.3, is a concept map which I developed for use in a basic geology class to show the concepts and interrelationships associated with the changing movement of the Earth’s crust. This concept map summarized an entire chapter and could be used as an introduction to the chapter. An instructor could frequently refer to the map as the class progressed through the chapter—always referring back to the big picture and how things fit together.

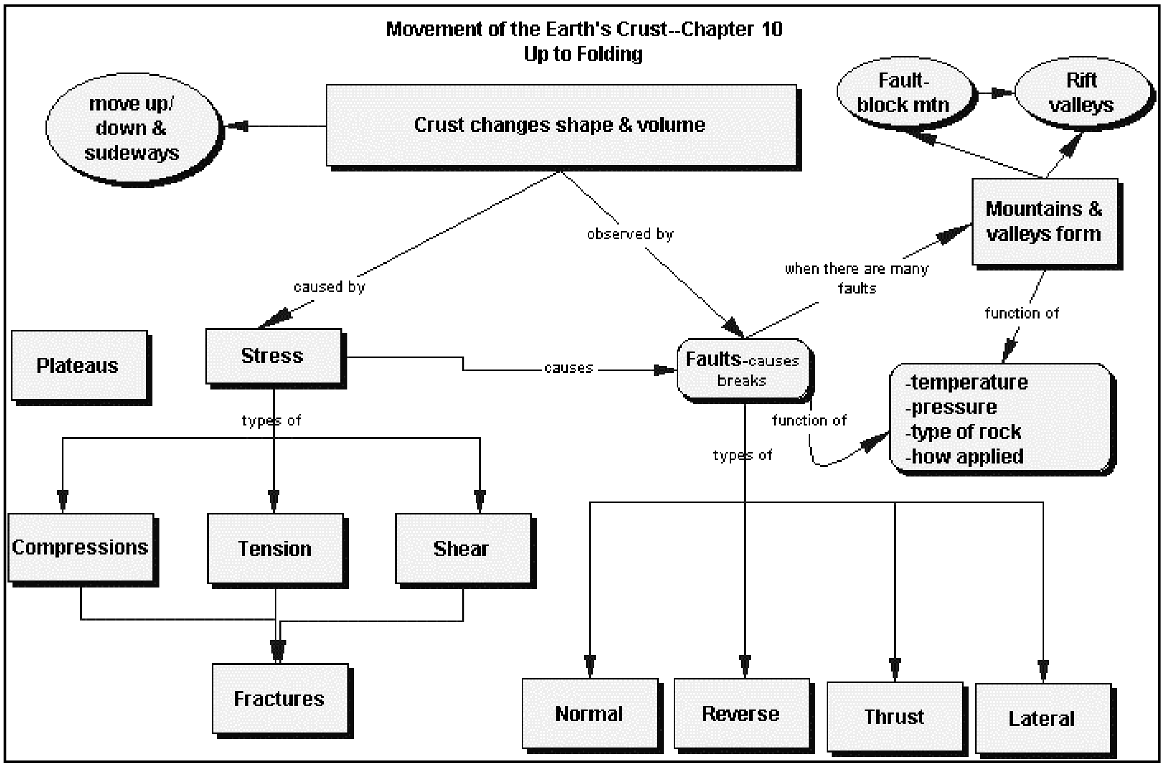

Figure 2.3 A concept map used to show interrelationships between concepts associated with the movement of the Earth's crust in an introductory course in earth sciences

Instructors can employ concept maps in a variety of ways in the classroom. For example, Weisenberg (1997) describes how instructors and students can employ Post-It notes to construct concept maps in the classroom. A number of computer programs have been developed that can be used to construct concept maps.

The reader is encouraged to review a number of additional references about concept maps and how they can effectively be employed in the classroom. There is an excellent overview of concept maps and other visual learning strategies in Chapter 5 of West et al. (1991). There are also several references on concept maps on the WWW such as Gaines and Shaw, (1995); Lanzing (1997); The Educational Development Resource Centre; and Plotrich (1997). These references were found using the "search engine" hotbot.com with key words *concept maps,* and they are listed in the Annex to this book.

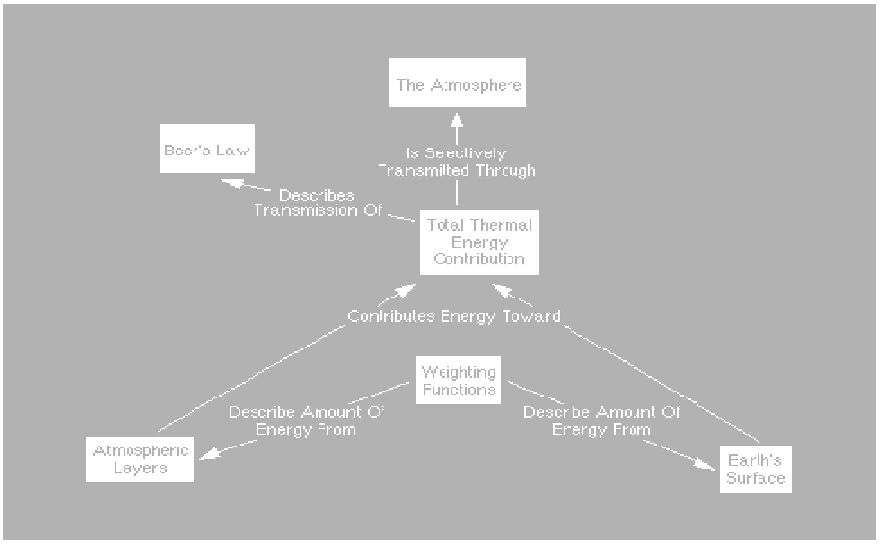

Figure 2.4.This concept map is an example taken from COMET's© CD-based module titled, *Satellite Meteorology: Remote Sensing Using the New GOES Imager* (Dills, Wang, and Menzel, 1996).

It's a good idea to employ pre-instructional techniques in each lesson. They need not be extensive or elaborate, but students are better able to focus their attention on the upcoming lesson if a few minutes are spent in this phase. Let's now see how we go from the pre-instructional step to creating an active learning environment where we combine instructional strategies with teaching formats and, when effective, use educational technologies.

FROM HERE TO THE CLASSROOM: *Concept maps…The drawings that are shown in Figs. 2.3 and 2.4 were developed using a software package called Inspiration. This excellent drawing program has many uses for instructors. The WWW link for Inspiration is www.inspiration.com. The reader might think she/he does not have enough time to create concept maps for each lesson—this is very true. However, if you teach the same course routinely, you might consider developing one or two concept maps the first semester, use them in class, and ask your students to evaluate their value. If you have success, then plan to introduce a few additional concept maps or other pre-instructional techniques each semester or quarter.*

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course routinely, you might consider developing one or two concept maps the first semester, use them in class, and ask your students to evaluate their value. If you have success, then plan to introduce a few additional concept maps or other pre-instructional techniques each semester or quarter.

2.5.3 Selecting the instructional strategy

Up to this point, the instructor has determined the objectives and the content of the lesson or block of lessons and classified each segment of the content into one or a combination as shown in Table 1.5 (Chapter 1) (fact, concept, principle, or procedure). In addition, you have selected the appropriate pre-instructional techniques and the best sequence of the lesson. You are ready now to match each of the content segments with an appropriate instructional strategy. The instructor applies an instructional strategy so that the student learns the content in the most effective and efficient manner and produces reliable results each time the content is taught (Kemp et al., 1998).

The instructor can apply several key instructional strategies, but not all strategies are appropriate for each content classification. In Table 2.5, the author divided each possible content element against one or more instructional strategies. Following the table, each of the strategies will be discussed briefly. In the following section, the next step in designing the lesson will be on the type of format that the instructor can use to apply the instructional strategies. Finally, we will explore ways that educational technologies might be applied in selected situations.

If the instructor wants the learner to…	**Then the content is classified as…**	**You might use these strategies…**
Recall or restate facts	• Facts	• Recall • Retention, rehearsal, review, or mnemonics.
State or apply concepts, procedures, or principles	• Concepts (fronts, tropical cyclones, classification of clouds) • Procedures (plotting a SkewTlogP diagram) • Principle (Ideal gas law) • Cause and effect (why are there no tropical cyclones in the South Atlantic) • Predictions (forecasting)	• Paraphrasing (integration) • Generating questions or other examples (integration) • Relate new knowledge with existing structures (integration) • Outlining key ideas/ structures (organizational) • Using tables to organize key ideas (organizational) • Concept mapping (elaboration) • Rephrasing into student's own words (elaboration) • Case studies
Higher-order learning	• Forming ones' own forecast process, using generic procedures as a basis	• Designing a simple-to-complex sequence for the skill and spanning a wide range of domain-specific content • Case studies/laboratory exercises

Table 2.5. Identification of instructional strategies for specific content elements.

Let us now expand a bit on each of the instructional strategies listed in the last column of Table 2.5. Each of the strategies described below belongs to a category of instructional strategy called *generative learning* (Jonassen, 1988; Lebow, 1994).

2.5.3.1 Recalling Facts

The most basic content that your students will be required to learn will be facts or lists of facts. Generally, instructors should use this minimally since it requires the least amount of cognitive effort and does not promote deep understanding of the content. Learning facts has its place, but in today's world where so much information is readily available through the WWW and exhaustive reference books, it can at times be more efficient or effective for students to know *where to get information* rather than learn it. When students are required to recall facts, instructors might employ rehearsal, repetition, review, or the use of mnemonics (see (Leshin, Pollock, & Reigeluth, 1992) for excellent examples of this technique).

2.5.3.2 Integration, Organization, and Elaboration

If the instructor wishes to teach concepts, principles, procedures, or an understanding of relationships (the same as principles), one could employ one or a combination of strategies. Integration is a term used by (Jonassen, 1988) to describe a technique where the learner transforms content into a more easily remembered format. For example, if the teacher described the equations of motion in mathematical format, one might ask the students to paraphrase or transform the meanings of each of the equations into their own words. In this way, the instructor would assess whether they understood the relationships. Another technique in this category of strategies is to ask the students to develop their own questions about concepts, processes, or procedures.

Organizational strategies include *outlining* or *categorizing new content* in the students' own words. An instructor can use tables (or students can use this technique to study) to divide key elements of concepts into its components (West, Farmer, & Wolff, 1991).

Finally, elaboration is a powerful instructional strategy that teachers can use when teaching concepts, principles, understandings, and procedures. This technique requires students to interpret and recount new ideas in their own words or diagrams. For example, a teacher could use a concept map to describe the factors that contribute to the formation of tropical cyclones. Or, better yet, the teacher might give a short lecture or discussion on the formation of tropical cyclones or students could explore the topics from a number of articles or web-based references. At the conclusion of this lecture and/or exploration, the teacher might ask students to work in small teams to "diagram" the relationships between factors and how a tropical cyclone forms, moves, and dissipates. These concept maps become a visual and mental picture of the formation process that may help students internalize the processes better than from just hearing the lecture.

2.5.3.3 Higher-order learning

Higher-order learning skills are at the top end of the cognitive skills that we hope our learners grasp and use. The most observable trait that the instructor might see from her/his learners is their ability to collect, analyze, diagnose, and correctly forecast critical weather events. An instructor can lecture, show, and practice numerous times with a canned forecast process, but in the end, it is the novice forecasters who have to figure out for themselves how best to order the data and determine *their* method of forecasting. It is this process with which higher-order learning is concerned. As it turns out, the literature is vague in what learning strategies best work. (Leshin et al., 1992) point out a few ideas:

- Design a good simple-to-complex sequence for the skill that must span a broad range of domain-specific content.
- Break each sequence into small, discrete steps that are taught on a given level of complexity and then brought together into a whole picture.
- Use a combination of expository vs. discovery and deductive vs. inductive teaching methods.

This concludes the short discussion on instructional strategies. At this stage, we are ready to select the best format for the lesson and this is discussed next.

2.5.4 Determining the optimal instructional format or delivery method

In this discussion, three possible (there are more, of course) instructional formats will be described: the lecture, small-group collaborative teaching, and self-paced learning.

Despite the fact that the lecture remains the most dominant instructional format, the author asks that each reader consider some of the potential negatives of this favored format. Overall, how do students normally react to lectures? Do you remember how you felt toward lectures? Do we use this because it is the way we were taught? Or, if the reader has tried innovative formats, did they return to the lecture because it turns out to be quite easy and flexible?

From my experiences, I can honestly say that the lecture is a good technique in comparison to collaborative learning, problem-based learning, and development of self-paced instructional programs (CAL lessons). In addition, some students prefer the lecture because they can attend class, take notes, and repeat the information on the next quiz. There are distinct advantages to the lecture, but on the other hand, there remain many disadvantages.

Small-group collaborative/cooperative learning involves students teaching students while the instructor moves from the center of the process to a facilitator or coaching role. Cooperative or collaborative learning is a very powerful learning technique and can nicely complement instructor-centered teaching. Despite the many advantages, a few disadvantages must be considered.

Finally, students can work independently in a self-paced format in the classroom, computer laboratory or away from the classroom outside the normal class hours (a format that might be called flexible learning in contrast to distance learning where students and instructors are well outside eyeball-to-eyeball contact). Again, there are certain problems related to this format while many advantages abide.

As a way to compare these three instructional formats, the author has developed Table 2.6 that shows each format along with its advantages, disadvantages, and possible uses. This text does not permit a full treatment of each of these important learning formats. The main purpose is to introduce the formats and provide sufficient detail for the reader to realize the variety of techniques available and to distinguish the advantages and disadvantages of the formats. The Kemp model provides an excellent overview of these formats while a number of the supplemental references go into extended detail about each one.

To wrap up the instructional design steps needed to deliver the lessons, the reader is directed to the last section—the integration of educational technologies into the classroom.

Format	Advantages	Disadvantages	Possible uses in the classroom
Lecture	• Relatively easy to develop • Easy to modify • Familiar to all • Instructor maintains control • Can be motivating	• Learner is passive • Requires highly engaging personality by instructor • Not all learners comprehend information equally. • Can be inconsistent from one lecture to another. • Interactively limited	• Lectures can be made to be interactive (see references)
Cooperative/collaborative groups	• Highly interactive • Students engage in content by discussing and listening • Teacher can identify misconceptions by listening to students • Can be highly motivating for students. • Students can synthesize complex content • Helps develop team building and social skills	• Takes a lot of time to develop techniques. • Learners nor instructors familiar with format • Time is critical and can run short depending on length of group time and presentations • Difficult to grade, if required. • Requires careful planning	• Can be integrated with pre-test and short, mini lectures. • Panel discussion • Guided design • Case study • Role playing • Simulation • Debate • Problem-based learning techniques.
Self-paced	• Highly interactive • Learners often work harder • Provides time for instructor to assist slower learners • Can be efficient if no changes are made and program can be used repeatedly.	• Extreme in the time required to develop • Costs can be high • Requires reliable computer facility and support • Reduced interaction by instructor and student.	• Can be integrated with mini-lectures. • Segments of modules can be used as presentation aids.

Table 2.6. Characteristics of three learning formats

2.5.5 Process

The instructional process (see Figure 2.2) is one that is discussed by Diamond (Diamond, 1997). It involves a number of options that training centers and instructors might consider, but will not be detailed in this text. The reader is encouraged to review this section of Diamond’s text for details.

2.5.6 Selection and use of educational technologies

In Chapter 3 the importance of using information or educational technologies for specific purposes is discussed. The author presents there a number of excellent situations where technologies could be used to solve a specific problem. Let us recap, for a moment, why we should use technologies in the classroom. Following this brief recap, we will then discuss when one or more technologies might be used to supplement the lecture or laboratory setting.

2.5.6.1 Why use education or information technology in the classroom?

In section 3.2.1 of Chapter 3, the author describes four reasons why instructors might wish to use technologies in the classroom. Using these reasons as a foundation for making decisions (there are factors that must be considered, as shown in Chapter 3), we will next discuss how technologies can be used in the delivery phase of our training programs. We must, however, keep in mind that the instructor has to solve many challenges, including the integration of technologies into the classroom. In the section below, we will describe how technologies might help solve these problems

2.5.6.2 Integration of technologies into the classroom.

We will now explore how educational technologies might help solve some hypothetical problems faced by instructors. Each potential problem area will be briefly described followed by ways that many of the technologies discussed in Chapters 2 and 3 could help the teacher solve the problem.

Situation 1: The instructor already uses a variety of teaching aids such as clips from video tapes, one or two WWW sites accessed on-the-fly from a browser, a few graphics viewed on a paint program, overhead projector slides and a number of 35mm slides. Her lectures are well organized, but due to the variety of media, our instructor spends time switching back and forth between the different media. This is distracting to the students and reduces the amount of time she can spend interacting with students. Do educational technologies provide for a solution for her problem?

Our instructor can employ perhaps two solutions using technologies in this case. Both involve converting all or large portions of her lecture material into digital presentations using the WWW, an authoring program, or a combination of the two. Both options have advantages and disadvantages that center on time required to convert and program the content, the availability of software, and training time for the instructor.

Solution 1, the simplest, involves developing a course homepage that would include as much as the content and media of the course as possible. Table 2.7 describes how the content and media could be converted, possible programs to use, and advantages and disadvantages.

Media/content	Programs to use	Advantages	Disadvantages
1. Design a course homepage. 2. Lecture notes converted to MS PowerPoint slides 3. Overhead slides scanned and converted to .jpg or .gif format. Embedded into PowerPoint slides 4. Video clips converted to .avi, .mov	• MS FrontPage, Adobe PageMill, HTML, or other web authoring programs—used for developing the basic course homepage. If you plan on maintaining an extensive, multipage program, FrontPage is excellent. Also if you use any of	1. Allows instructor to access most if not all content comes from one location. 2. Students can submit problem sets or other presentations that can be imported into webpage for presentation in class. 3. Once program has been developed, it can be used many times, which reduces lesson preparation time.	1. Takes time to learn programs and convert content. 2. Some programs can be expensive. 3. Requires updating programs. 4. Requires some updating of content as instructor revises lectures. 5. RMTC or training office should have support staff to maintain equipment.

(Quicktime), .mpg (MPEG), or other digital format—see Chapter 3. 5. 35mm slides scanned or converted into Kodak Photo CD format. Images can be converted to .jpg or .gif format.	the other MS programs (Word or PowerPoint) FrontPage allows you to efficiently access these programs on-the-fly in class. • A scanner and software package such as Adobe PhotoShop can scan, edit, and convert into a number of formats. Finished images can be inserted into the PowerPoint slides or into the web pages. • A video conversion program is required. For more than 5 minutes, the video player may remain the medium of choice.		

Table 2.7. Possible solution to a instructor's problem using technologies

The second solution is more complicated and will require additional time by the instructor to develop, but one of the advantages is that the solution offers more flexibility for teaching. The main differences between the two solutions are as follows:

- In addition to the course webpage, the instructor would use an authoring program such as Asymetrix's ToolBook Assistant to create either a course or individual lessons programs, each consisting of a number of pages.
- Each lesson could be outlined into one or more menus allowing the instructor to organize specific content around these menus.
- As part of the African Satellite Meteorology, Education and Training (ASMET) and Universidad Metropolitan de Puerto Rico (UMET) programs, COMET staff designed a series of templates so that instructors would not have to start from scratch, but had a rough course and lesson structure.
- Most of the media can be inserted directly into such as program. Video formats such as QuickTime and AVI are supported while others are not supported (as of this writing) such as MPEG.
- The primary advantage of this solution is that the entire lesson is contained within a single program. Since all media are in one program, the instructor's time in class is more efficient, leaving more time for dialogue with students. Revisions or additions to the ToolBook program can be accomplished using the course webpage. The course homepage is a good place to organize the syllabus, course schedule, and assignments.

- The main disadvantage, in addition to the one outlined for Solution 1, is the extra time required to learn ToolBook or a similar program, and the time needed to design the lesson pages and insert the media.

This author and a colleague have used both of the techniques and can testify to the advantages and disadvantages. Recently, he used the course/lesson template designed from ToolBook Assistance titled, *Course Materials Toolkit*. With some experience, it seems that this might be very effective for converting a multimedia lesson from separate display devices into a single program.

Situation 2: The instructor wishes to reduce the amount of lectures in class and provide her students with more opportunities to learn on their own. Could she use and integrate educational technologies to help solve this problem?

A solution to this problem could be a combination of the solution to Situation 1 with the integration of one of the existing CAL programs. Rather than a lecture, the instructor would structure the lessons using a variety of formats such as self-paced CAL programs, small group activities, and mini-lectures. Let's assume that the lessons under question focus on tropical meteorology and specifically how satellite imagery can be used in analyzing the ITCZ and other tropical features. Table 2.8 describes how our instructor could solve this problem using a variety of technologies.

Media/classroom format	**Programs to integrate**	**Advantages**	**Disadvantages**
Self-paced learning combined with lectures on specific topics related to the CAL or web-based learning (WBL) content.	• *ASMET I and II CAL programs* • WBL assignments linked to web sites. • Completion of *PC Erin* a case study of Hurricane Erin that formed in the NW Atlantic Tropical Cyclone basin.	1. Each student is responsible for learning materials from CAL programs. Instructor can develop a series of lesson questions or quizzes linked to CAL programs.	1. Requires RMTC to be equipped with multiple workstations for CAL programs. 2. Requires time to design lessons around existing CAL materials. Some content may not exactly fit current syllabus. 3. Requires instructor to review all CAL programs and determine best fit for lesson objectives.
Same as above, but using a Small-group learning format	• Two-person teams complete the programs mentioned above, then discuss results in class.	Same as above in addition that collaborative learning is introduced.	1. Same as above 2. Requires instructor to learn how cooperative/collaborative learning can be used in course.

Table 2.8. Solution to training problem using and integrating technologies into a course.

Our next situation is similar to the one above, but solves a different problem in that the expertise does not entirely exist at the training center.

Situation 3: The student's home offices have informed RMTC management that they want their students to have two courses on marine meteorology. This is fine, but it *is apparent that none of the RMTC instructors have experience in marine meteorology topics such as sea and swell forecasting, how to detect and forecast low visibility conditions at sea, nor basic physical oceanography topics.*

If students are required to learn how to make sea-state (wind waves and swell) forecasts and the instructors at the training center do not have the background or experience, the training center must provide the expertise. In the short term, CAL programs could be used in conjunction with introductions by the instructor's limited experience to accomplish the job. For example, COMET's© *Marine Meteorology Series*, along with several web-based resources could be used as course content. The format of the lessons could be the same as shown in Table 2.8. The same advantages and disadvantages hold true for this situation, except that our instructor must take time to complete the same content as used by students.

Situation 4: Several instructors have collected case studies that represent important processes or forecast situations. These case studies consist of a variety of media including paper surface charts, upper air charts, and thermodynamic charts, satellite data, and numerous other data. The data are getting tattered, it also takes time getting the data together for each class, and there aren't enough copies for students to work on. Can technology be used to improve this situation?

Case studies are critical for studying our science and can be used effectively as part of courses. As more and more elements of a case study are digital files, how can our instructor capture case studies in a format usable in class? Technologies might be a solution to consider. The (ASMET) project produced three important products. The first two were CAL programs that can be used as part of a course (see situation above) while the third program was a case-study engine or template. This program is suitable for developing a case study into a format that can be used as a lecture aid or self-paced learning module. Elements of the case study would have to be converted into formats supported by the program then inserted using very simple commands. The program is very simple to use, but does require time scanning and/or converting existing content into the necessary formats. Once the case study is complete, our instructor or his colleagues can reuse the program without repeating preparation time.

All of the above situations are challenges, but each one can be accomplished within the training center. We are teaching resident students who used a variety of technologies controlled by the instructors. In our last situation, we confront a situation that will eventually face every national training center and RMTC—implementation of a distance learning program.

Situation 5: The directors of the meteorological services have asked the Principal of our instructor's RMTC to develop a series of refresher training courses for their forecasters and hydrologists. The training programs span from one to five days in length and cover a variety of contents including advanced satellite data analysis and forecasting, new advances in hydrology, and tropical cyclone preparedness training. Due to budget restrictions and reduced staffing, the directors have asked the Principal to deliver these courses at-a-distance. How can technology be used to solve this problem?

This situation is the most challenging to solve as it involves all of the solutions to the previous situations plus some very complex issues involving distance learning. Our RMTC staff can solve this without technology, but technology will, in the long run, be the most effective and efficient route. In Table 2.9, we explore how technology could solve a few of the many elements of this problem.

Media/content	Program to integrate	Advantages	Disadvantages
1.Existing lectures can be converted to self-paced lessons including explanations and assessments. Or new distance learning lectures could be designed for the specific audience and subject content.	1. Web-based or other authoring programs such as in Situation 1, Solution 2. Programs could be distributed over the WWW or CAL programs mailed to offices to be completed by students.	1.Forecasters and technicians can maintain proficiency in numerous topics without traveling to the RMTC. 2. Once the materials are developed, they can be used repeatedly.	1. Takes time to design and develop. 2. Support staff needed. 3. The same equipment as discussed in previous situations is needed.
2. Dialogue could be established between learners and instructors who are separated by distance so that on-line lectures and discussions are possible.	2. WebBoard programs can be used to conduct asynchronous discussions. MS FrontPage has this capability, as do other programs on the market.	Software is widely available, but requires a server to maintain site. Software is generally easy to use.	Students and instructors are not familiar with this format so it requires some training and dedication to use. Instructors need to provide some structure to the WebBoard, as it cannot stand-alone.
3. The above could be combined with videoconference lectures using a network connecting the RMTC with NMHS offices in the region.		3. Today, most equipment is based on standards allowing all sites (using different vendor's equipment) to communicate.	This can be expensive since it requires videoconference equipment at both sites in addition to support staff. Requires time to research the options and develop a strategic and implementation plan.

Table 2.9. Possible solutions using distance learning technologies

These are but a few instances where technology might be used to solve specific teaching and/or learning problems. No doubt, instructors can think of additional solutions, which might better apply to their circumstances. Some of the above situations were real, others bent toward the hypothetical. However, in every situation, the solutions were based on elements experienced by the author or told to him by colleagues from RMTCs.

2.6 Summary

In this chapter, we have focused on techniques that instructors can use to deliver effective and efficient lessons in the classroom. The concepts and techniques described by the Kemp and Diamond ID models can be used as a general guide. We discussed the selection of an instructional format that was based on our instructional objectives combined with sound instructional theory and principles. Further, the instructional format was based on four elements: the best sequence, different delivery formats, instructional strategies, and the process to follow. Finally, we considered five situations where educational technologies could be integrated into the delivery of instruction. It is the author's hope that the guidance offered in this chapter provides help for new instructors as well as serve as a refresher for experienced teachers.

Each institution should obtain copies of the Kemp and Diamond's texts, as they provide additional detail. Ultimately, however, each instructor is responsible for deciding on the best course of action in delivering his or her lessons.

2.7 Glossary - terms used in chapter 2

The writer has provided a brief definition to some of the less familiar terms used in this chapter.

Self-paced learning is where the learner works independently on lessons that have been carefully designed by the instructor. The lesson is completely contained with the self-paced lesson. The instructor's role is to design the lesson and provide guidance at the beginning of the lesson.

Web-based learning (WBL) is instruction that is delivered using the World Wide Web. WBL can include links that the student requires to complete a lesson or entire lessons designed using the WWW, as with a self-paced learning lesson.

WebBoard is a program that provides asynchronous communications between instructors and students using the WWW. Another common term for a WebBoard is a threaded discussion. These programs are similar to a *chat* or *listserv* format, but are more structured and organized in that the instructor can ask specific questions (a thread) and ask that students respond with answers or additional questions on each specific question or discussion topic. Each question by the instructor (thread) and corresponding answers by the students are threaded together.

Videoconferencing is one of the growing distance learning technologies. A common videoconferencing technique is called compressed videoconferencing and uses dedicated high-speed communications lines. In the transmission process, the bandwidth is reduced by transmitting digital images that have had redundant information eliminated. The amount of compression determines the image quality. Two excellent references for using compressed video are by Hakes et al. (1995) and Moore and Kearsley (1996)—see the reference for details. The writer has designed and conducted lessons using compressed video with excellent results in higher education. A brief summary of this effort is included in the reference section, Heckman et al (2000).

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Chapter 3: Using educational technology in training

3. Introduction

This chapter considers the impact that technology can make on training. Various phrases, such as "educational technology" and "communications and information technology" are often used in this context. In short, these refer to the use of technology to support education and training.

Much of this chapter is devoted to technology but it is essential that the technology is seen as a means of providing high quality training – it is not an end in itself! Technology should never be used just for the sake of being different or trying to appear up-to-date, it should be used when it can increase the number and quality of learning opportunities and empower people with different learning styles.

Throughout this chapter the term "conventional training" is used to refer to training which does not include the use of technology. Of course, this is not always correct as many people incorporate technology into the conventional teaching and learning that they do every day. The phrase is used here as a shorthand reference to training based on lectures, tutorials and practical classes which do not require technology.

When faced with conventional and technological approaches a trainer does not have to decide on one or the other. The choice is between the best of both approaches and the solution will often be a judicious mixture of both.

The chapter begins with a section defining the various types of technology used in training. Each of these sections contains a brief case study as an example of the use of the technology. The chapter is completed by two sections discussing the circumstances in which to use educational technology and the institutional issues which need to be addressed to introduce educational technology successfully.

3.1 What are the appropriate educational technologies?

Educational technology, the computers, networks, audio and video devices that are useful in training are in a never-ending state of change. It is virtually impossible to write a description of educational technology without it being out-of-date almost immediately. The following sections concentrate on the fundamentals of the technology. Most emerging technologies are based are based on these fundamentals. Some items of rather more historical interest are useful in indicating trends.

3.1.1 Multimedia computers

In 1992 computers were already being used in some institutions for meteorological training. Many more institutions were interested in starting to use computer-aided-learning (CAL). The major problem at that time was that few people owned multimedia computers and there were many definitions of what constituted multimedia. The computer industry recognized the problem and defined MPC (multimedia personal computers) which all met a standard specification. This standard has undergone two revisions and (at the time of writing) MPC3 is the standard specification for a multimedia computer. The key components of the MPC3 are:

- CD-ROM drive
- Audio capability
- Video capability
- System specification

New computer purchases should always adhere to the current MPC specification as software producers often use these specifications when designing new packages. Let us consider each of the elements of a multimedia computer and its relevance to training.

3.1.1.1 CD-ROM

CD-ROM means Compact Disc - Read Only Memory. A CD-ROM is a digital disc which stores data on compact disc, the same medium as music on CD. The capacity of a single CD-ROM is 650 Mbytes (equivalent to 74 minutes of music on a CD). The storage capacity is therefore more than 450 floppy discs. Since CDs were originally used to play music they needed to deliver data at a fixed rate, 150 Kbytes/s. Although this is adequate for music it is rather slow for data. In a computer CD-ROM drives soon appeared which offered greater speed, initially x2 or x4 but eventually x24 or more. The MPC3 standard requires at least 550 Kbytes/s (x4). As CD-ROMs became widely used a number of different formats developed. MPC3 computers must be capable of reading many different formats – the main variants are:

- Red Book: the format used originally for all music CDs
- CD-ROM data in single and multi-session (i.e. written in separate sessions)
- CD-ROM XA: Extended architecture CD-ROMs used for some data
- Photo CD: Kodak's format for images written to CD-ROM from photographic film
- CD Recordable (CD-R): MPC3 computers should be able to read (but not write) recordable (write-once) CD-ROMs
- Video CD: Used for feature films on CD
- Enhanced Music CD: In addition to music the CD may also contain text, images and video
- CD-i: CD-Interactive, a format for interactive games

One of the great advantages of CD-ROM over other bulk storage media, such as tape, is very fast direct access to any point on the disk. MPC3 computers should be capable of an average access time of 250 ms.

Case study*: A meteorologist in Australia wanted to send images from nearly 200 35mm slides to a colleague in the U.K. He gave the slides to his local photographic shop and asked for them to be processed onto Kodak Photo CDs. Each Photo CD holds up to 100 images in five different resolutions up to more than 3000x2000 pixels. The images could be sent without risk of damaging the slides and the cost low. The digital image quality is sufficient even for high definition printed material.*

The high volume and low cost of CD-ROMs means that this is by far the most cost-effective way of delivering digital material. Many organizations use CD-ROM to make extensive data sets available and a significant number of training modules are also now produced on CD-ROM.

The capacity of a CD-ROM is limited to 650 Mbytes. However, it is technically possible to store more data on these discs. To exploit this, a new format called Digital Video Disc (DVD) was developed. The word "video" is in the title because this new format allows a whole movie to be stored on a single disc. A DVD-ROM can hold about 7 times more than a CD-ROM (4.7 Gbytes) in a single layer and some have a dual layer format which doubles this. A DVD looks exactly like a CD-ROM disc and many computers come fitted with a DVD disc drive rather than a CD-ROM drive. In general this is good since it provides greater capacity and a high degree of compatibility with CD-ROM. All DVD systems will play CD audio and CD-ROM discs. However, early versions of DVD drives did not read Photo-CD or some CD-R or CD-RW discs.

3.1.1.2 Audio capability

MPC3 computers are capable of producing the same quality of audio as is found of music CD systems. This is specified as 16-bit audio sampled at 44.1 kHz in stereo. Although music is sometimes used in computer-based material for meteorological training, the use of speech is much more significant. Meteorologists frequently need to study graphical data in the form of satellite or radar images, contour plots or graphs. It is much more effective to describe these images audibly while the computer screen can display the graphical data at its highest possible resolution, than to waste some of the screen space with a textual description which also distracts the eye from the main objective.

***Case study**: In the computer-based training materials produced by COMET recorded speech is often used as part of a training approach known as "cognitive apprenticeship". Although the learner is working at a computer and concentrating on the screen, the pre-recorded speech is from an expert and is guiding the learners (apprentices) in their learning. This approach is so natural it is common for people to work for much longer periods with audio tuition than with a text-based system which requires more effort.*

Audio systems on computers usually include stereo speakers but in an educational or working environment it is often better to use headphones. Multimedia computers support full duplex audio: it is possible to speak as well as listen and both are possible at the same time. While meteorologists rarely need to speak when interacting with computer-based training, unlike for example air traffic controllers, there is a role for two-way communication in audio and video conferencing (see later).

3.1.1.3 Video capability

Video can play an important part in training meteorologists and a significant step forward in the use of computers to present video material came with the MPC3 standard. Before MPC3 it was possible to play video material on computers but there were many different formats and these varied a great deal in quality. The best quality could only be achieved by special hardware (video overlay cards). With the MPC3 standard came the requirement that multimedia computers should support MPEG1 video. MPEG (Motion Picture Expert Group) is an ISO standard for digital video. The MPC3 requirement is that a video image of 352 x 240 pixels should be playable at a frame rate of 30 frames per second with at least 15 bits used to represent the colour of each pixel (or 352 x 288 at 25 frames per second). In order to play this video stream, representing a data rate of about 5 Mbytes/s, from a CD-ROM with only about 0.5 Mbytes/s transfer rate requires that the video format is highly compressed and that the computer is capable of uncompressing the data stream in real time.

Case study

3.1.1.4 System specification

The basic specifications for the RAM, hard disk drive size, processor, graphics and screen resolution are improving too quickly to give any recommendation. At the time the MPC3 standard was specified 8Mbytes of RAM, at least 540 Mbytes of disk, a Pentium 75MHz processor and a screen resolution of 800 x 600 with 64,000 (64K) colours were considered suitable. Such a specification would no longer be considered a basic computer.

Case study*: Ian Bell, of the Australian Bureau of Meteorology, produced a package to help people recognize cloud types. This included large numbers of examples of different cloud types, descriptions of the clouds' properties and the other types of cloud with which it could be confused as well as hints on night-time observations. The package also included a self-assessment test with additional cloud images. This type of package is possible because the computer is capable of representing high quality colour images which are instantly recognizable. The quality must be good enough so that those using the package should not have to accept any degradation which could cause problems in recognizing clouds.*

The choice of system specification should not be based on any standard but on the purpose for which the computer is intended. In most cases the software to be used will dictate the minimum requirements.

This entire section is based on the implicit assumption that PC computers are the automatic choice for training. For meteorologists, the PC is virtually a *de facto* standard in training establishments although in operational establishments Unix workstations are common. The section on the World Wide Web, later, will address issues of platform independence.

3.1.2 Common software packages

It is a mistake to think of the role of the computer in training to be primarily as a means of delivering computer-aided-learning packages. In fact, the use of standard "office" software packages can make an enormous impact on the quality of training materials and on the efficient re-use of materials. When materials such as lecture notes or diagrams for overhead projection are stored on a computer they are in a form which can be easily passed form one person to another and it is also easy for a trainer to modify the material to exactly his or her own purpose. Lecture notes can be updated, or suitable sections can be used in another course. Diagrams can be edited to add new features. Images and charts can be stored in collections, which represent detailed case studies, or the same material can be used in a different situation to illustrate a different point. It is the flexibility of the computer-based resource that makes its re-use much more likely than paper-based material. The following table lists some of the uses of common software packages:

Package	Example Use
Word processor	Production of lecture notes, assessment sheets, practical guidelines, etc
Spreadsheet	Data processing, simple model formulation, simple graph production from raw data
Databases	Indexing of training material for easy searching and retrieval, cross-referencing of material which is used on more than one training context
Presentation packages	Computer assisted presentations including the use of animations or simulations
Graphics packages	Image manipulation, including contrast enhancement and feature labeling

By using these standard packages the concepts of “resource sharing” and “re-use” become much more practical. It is much easier to share and re-use material if the trainer is subsequently able to edit it. In the past there has sometimes been resistance to using material produced by other trainers, because it is not exactly what is required. Now, it is recognized that part of the skill of trainers is to avoid wasting time by identifying re-usable resources and to create their own “added value” by adapting the existing material into the context which is right for their own trainees.

***Case study**: The UK Met Office College produced a database of all their lecture notes, visual aids, videos and other materials. This not only alerted everyone in the College to the enormous depth of material available but also drew the attention to those outside the College that these resources existed and were potentially available for sharing and re-use.*

Sharing and re-use of resources is not restricted to a single institution. The common world-wide training requirements of meteorologists creates a global community able to share and re-use training materials.

3.1.3 CAL programs

Computer-aided-learning (CAL) is a general term which can mean the use of computers to support any learning activity. However, it is used here in the slightly more restricted sense of describing the activity a trainee undertakes when interacting with a computer, using a program designed with the specific purpose of teaching. This is also known as computer-based-training (CBT), computer-based-learning (CBL) or computer-assisted-instruction (CAI).

CAL programs can be used in many contexts but they are usually used in situations where the learner has control over the pace at which they work. Often this is associated with being able to work at a time which suits the learner: extra revision time after other forms of training; fitting in some training at work or at home; learning some new skills just before starting a new job. Good CAL programs not only provide the knowledge the learner needs, but also provide opportunities to practice that knowledge and give feedback on the actions of the learner.

Production of CAL programs usually requires a team of people with a wide range of specialist skills (subject expertise, pedagogical expertise, programming expertise, graphics design skills). It is usually expensive to produce CAL and so the programs produced need to be used by a large number of learners to make them cost-effective. If a small organization plans to use CAL in its training then the options are:

1. find CAL which is suitable and has already been produced
2. collaborate with enough other people to make it worthwhile producing your own
3. go ahead and produce it anyway but make it available to others, they will then be more willing to share their programs with you

It can be difficult to find CAL programs which exactly fit your training needs if you have had no influence on their design. An attractive option is to find CAL programs which you can modify to your needs. In general this is difficult but in some simple cases such as presenting and discussing satellite images or presenting quizzes for self-assessment it is possible to obtain “content-free” CAL programs. These are programs which each trainer can use by supplying the content they want their trainees to see.

There are several sources of CAL programs for meteorology which are freely available (CALMet, http://www.met.ed.ac.uk/calmet). These are usually small programs which can be used in a variety of contexts. Other, more substantial CAL programs are also available (COMET, EuroMET) which are intended to fulfil a complete training topic.

***Case study**: EuroControl, the European Air Traffic Control organization has produced a single CD-ROM which covers the entire Meteorology curriculum required of air traffic controllers. This comes with a handbook which is also available as on-line help. The CD-ROM contains about 160 interactive exercises and can be used by trainees in their own time or in a classroom. Delivering a complete course in this fashion is only possible when the learning objectives of the entire group of learners are very clearly defined – as it is in this case.*

CAL programs are also described in the later sections on authoring tools and the World Wide Web.

A very important aspect of CAL programs is that, used in isolation, the learner can fail to obtain suitable assistance when they need it. Learners who are working on their own and using computers need to be able to communicate with others in order to ask questions and get specific feedback to their own problems. Thus, CAL programs should not be considered as a complete teaching medium but only one component.

3.1.4 Network technology

The benefits of computers in training can be greatly enhanced when they are connected to a network. Networks may exist on several different levels: within a work group, or within an organization, or connecting several organizations in a national or international network. The Internet is simply a network of connected networks which spans the world. It grew from a single network in the US in 1981 to a world-wide network connecting an estimated 30 million computers in 1998. The number of computers connected to the Internet is still approximately doubling every year. The figure below shows the countries with Internet connectivity in June 1997.

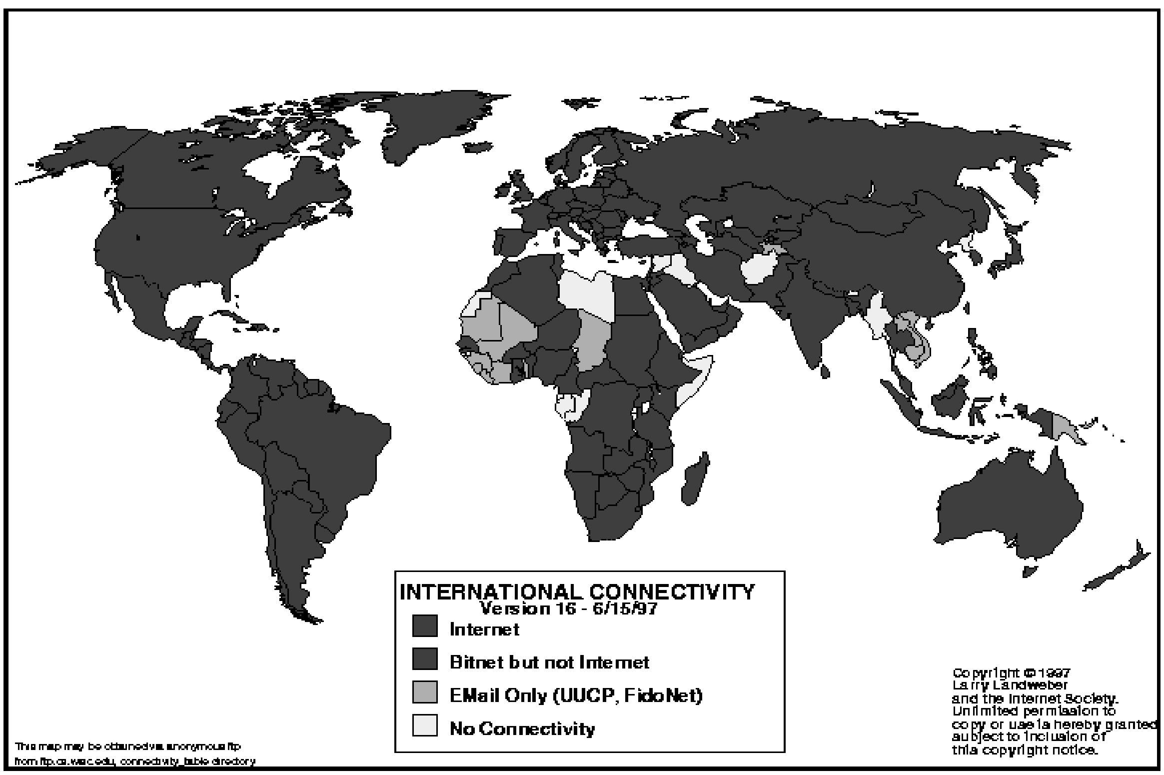

Figure 3-1: International Internet connectivity in June 1997. (With thanks to Larry Landweber and the Internet Society).

An individual computer or an institutional network can be connected to the Internet by an Internet Service Provider (ISP). This usually involves connecting at least one computer to a modem which is also connected to the telephone line. An individual, for example at home, can use their home telephone line to make calls from their computer to their ISP. A larger organization is more likely to hire a leased line which is permanently open and connect their entire network permanently to this line.

However, it is not only the physical connectivity of the computers that matters, it is the fact that they can communicate. People around the world use different types of computers and run different applications on their computers so protocols were established which were independent of these applications but which act as a common language through which they can communicate. There are several protocols for different purposes. Some of the best known are:

Protocol	Purpose
ftp	**F**ile **T**ransfer **P**rotocol: used to transfer files of any type between computers of any type.
smtp	**S**imple **M**ail **T**ransfer **P**rotocol: used to send email messages between computers. A wide variety of email programs all use the same protocol to ensure that all email messages can be written, transmitted and read.
http	**H**yper**T**ext **T**ransmission **P**rotocol: this is the protocol used to support the World Wide Web
nntp	**N**et **N**ews **T**ransmission **P**rotocol: used to transmit network newsgroups around the world

Even these protocols are too sophisticated to allow world-wide communication without some simplification. All of these protocols describe the “transport” of information, that is, the “packets” into which the information is packaged before it is sent. The Internet is based on using TCP/IP as its transport mechanism. The physical structure of the cables, optical fibres or telephone wires that carry the computer-to-computer connection are all capable of supporting the TCP/IP transport but they can do so in different ways depending on the physical structure. Some of the common mechanism are ATM (Asynchronous Transfer Mode), FDDI (Fibre Distributed Data Interface), SLIP (Serial Link Internet Protocol). Communication between applications on two Internet-connected computers brings all of these mechanisms into play as shown in the figure below.

Although this description applies to the Internet it also applies to any network, whether it is connected to Internet or not. A network within an institution is often refered to as an Intranet and these networks are usually very fast, unrestricted by the bottleneck of the Internet connection. Since the network protocols are available on the Intranet as well as the Internet it means that institutions can have their own World Wide Web (or Institution Wide Web) even if they are not connected to Internet. This opens up enormous potential for information retrieval and also for computer-based delivery of training from either central or distributed servers.

***Case study**: In 1992 the CAL Working Group of SCHOTI established an email list-server for people interested in Computer-Aided-Learning in Meteorology. Anyone wishing to join the list sends a ‘subscribe’ message and they are added to the list. All list subscribers can send an email message to the list and it is automatically copied to all the other subscribers. This is an example of how Internet communication permits “communities” to develop when the members of these communities do not initially know each other. An individual with an interest in CAL and meteorology can subscribe to this email list and is automatically a member of a group which now has more than 300 members in over 30 countries.*

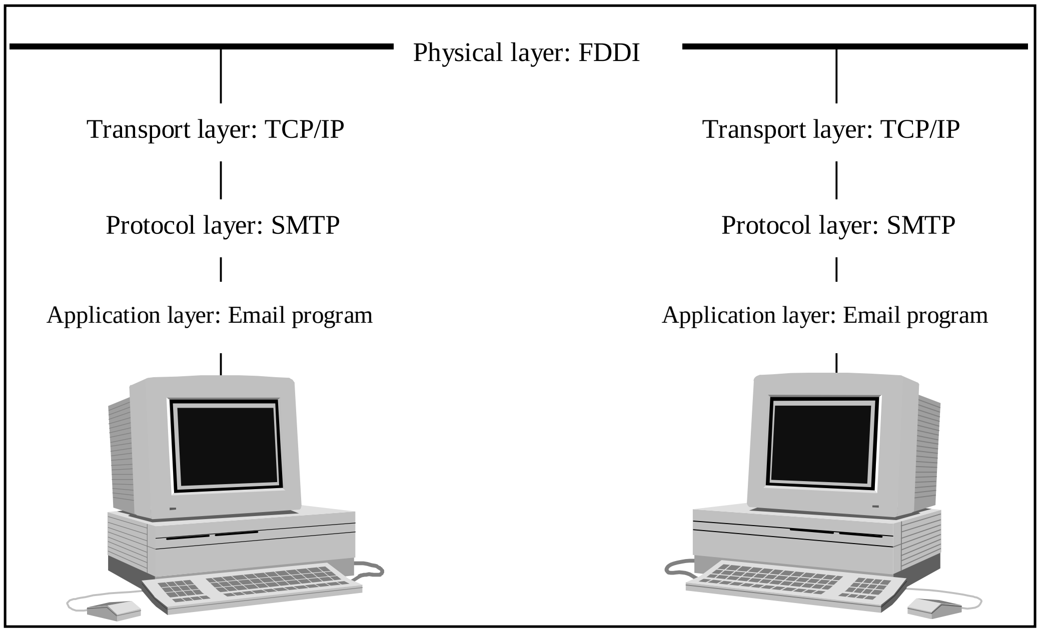

Figure 3-2: Communication paths between computer applications. The protocols shown at each layer are simply examples, other protocols are also possible.

3.1.5 World Wide Web

The World Wide Web, also known as WWW, the Web, or W3, is often confused with the Internet but it is really just one of several protocols supported by Internet. It has rapidly become the most used Internet protocol, probably accounting for between 70% and 90% of Internet communication. The Web is based on a client-server structure. If you are an individual searching for information on the Web then the software that runs on your computer is the client. This client software is usually a browser such as Netscape Navigator or Microsoft's Internet Explorer. From the browser you request a document from a remote computer. On the remote computer the server software recognizes your request and sends the document. The delivered document is then displayed in your browser. The connection to the remote computer is not maintained, it only exists to send the document and then it is lost.

The real power of the Web comes from the fact that the documents it supports are multimedia, hyper-documents. They are multimedia because the are not limited to text but can include pictures, video, sound, programs and even 3-dimensional virtual reality objects. They are hyper-documents because hypothetical links exist between points in one document and other documents. Clicking on one of these links loads the relevant document from its remote computer. In this case the remote computer may be anywhere in the world and is probably not the same computer that delivered the first document. Since information can be retrieved from anywhere in the world at the click of a hyperlink the documents are sometimes said to reside in hyperspace. In fact a vast number of Web documents now exist. In 1998 more than 2.5 million computers were acting as Web servers.

The key to finding information on the Web is the URL (Universal Resource Locator). This is a unique address capable of referring to a single file on any computer in the world. In fact it is also capable of locating a particular point in the identified file! The URL has the general form:
protocol://machine/directory/file#placemark

Since the Web uses the HyperText Transmission Protocol the first part of a URL is usually http. It can, however, be different because the Web can also support several other protocols. URLs need not include all of the details above. Sometimes the directory or file name is not known and it is very rare that an individual would know the placemark in a file. It is often possible to simply guess at the name of the machine for an organization and to locate their Web site from the guessed URL. For example, the WMO Web site URL is http://www.wmo.ch/ where www.wmo.ch is the name of the computer acting as the web server. These computer names are composed of several parts separated by a dot '.'. Reading from left to right, first comes the name of the actual computer (sometimes an alias) then the name of the organization, sometimes the name of the parent organization, then the network identifier followed by the country identifier. The WMO name is short because it doesn't have a parent organization or a network. Another example, which has both, is http://www.met.ed.ac.uk/, which is the Web site of the Meteorology Department, at Edinburgh University, on the Academic Community network, in the UK.

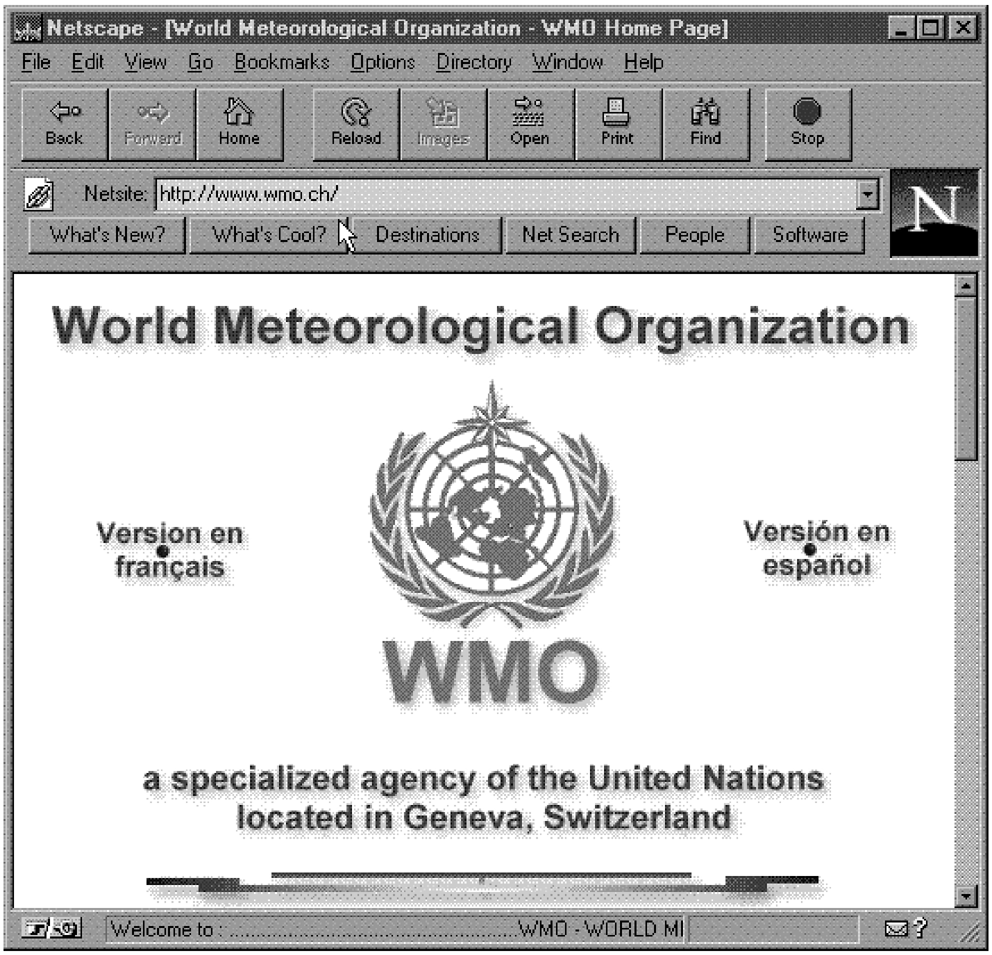

Figure 3-3: The WMO Web site as viewed through a browser with the URL near the top of the screen.

Why has the Web become so successful? Part of the success is undoubtedly due to the very simple user interface. To use the Web you need only read, identify links (usually coloured blue and underlined), and click on them. However, the most significant factor in the world-wide adoption of the Web as an information medium is the fact that it is platform-independent. No matter what type of computer you use, there is a Web browser available. The documents on the Web reside on specific machines, but server software is available for all the major platforms so information providers can create Web sites on almost any computer. The Web server software delivers documents which can be read on any computer.

Most documents on the Web are text-based documents written using HTML (HyperText Markup Language). It is because HTML is understood by browsers on all computers that the documents are platform-independent. Although these text-based documents can also support multimedia such as video and audio they cannot offer interactivity, other than clicking to receive another document. Several methods of providing more interactivity have developed. These fall into two categories, server-side and client-side, meaning that the program which performs the interaction resides on the server (remote) computer or the client (your own) computer.

CGI (Common Gateway Interface)	Server-side: The client can send a request to run a program and return the results of the program in a Web document. Before sending the request a form can be completed which contains data required by the program. This type of server-side program is particularly useful for gathering information for a central database or for providing access to a program which is platform specific (i.e. will run on the server but not on all possible clients).
JavaScript	Client-side: This object-oriented language can be used to interact with objects in the browser. For example, it can be used to move images, to change text or numerical data and to specify actions to be taken when objects are clicked. (Originally developed by Netscape but now also adopted by other browsers.)
Java	Client-side and Server-side: This is a programming language specifically designed to be platform independent. It is similar in structure to C++. It has built-in network capabilities and security. It is capable of many forms of interaction including drawing in the browser. Very interactive programs can be written and delivered through the Web to run on a wide range of different computers. (Originally developed by Sun Microsystems and supported by all major browsers.)
Plugins	Client-side: Plugins are used to allow specific manufacturer's software to run in the browser. They include audio and video support and interactive programs. They can only be used to display documents produced by a specific manufacturer's software and most of them are not platform-independent, though many will run on more than one platform.

Case study*: EuroMET (European Meteorology Education and Training) has produced training material to be delivered using the Web. It uses multimedia and is also interactive. HTML, JavaScript and Java were all used to ensure that the material can be used on any computer with a suitable browser. The material resides on Web servers in Toulouse and Edinburgh. This means that one of them should always be available. It is also possible to revise and update the material and everyone will immediately have access to the latest version without any action on their part. If some of the material takes a long time to load over the Web it is possible for institutions to transfer the parts they plan to use to their own Web servers, or to keep some on their own Web servers and get the rest from Edinburgh or Toulouse. In this way a distributed, but easily updateable, training resource can be maintained.*

3.1.5.1 Streaming media

The World Wide Web is used as a means of delivering hypermedia. This means that the material is not restricted to text and images but can include audio, video, animations and programs. Unfortunately, the way the Web is designed to work makes the delivery of more than a morsel of audio or video very laborious. When someone requests a video sequence on the Web it is treated in the same way as any other media. The file containing the video is delivered and, once it has been delivered, it is shown. If the video sequence lasts more than a few seconds then it will be a large (or perhaps enormous) file. There will then be a significant time delay between the request being issued and the showing of the video sequence, triggered by the delivery of the last part of the file.

Clearly, it is not really necessary to deliver an entire video file before starting to view it. If the rate of delivery is sufficient then the video can be viewed as it is being delivered. Highly compressed video sequences can be played in this way. After requesting the video there is a small delay while the first few seconds of the sequence are delivered. These data are kept in a buffer while the computer assesses the delivery rate and calculates whether or not it can play the video at the rate it is being delivered. If it can, then it starts playing the sequence from the data in the buffer while at the same time adding the incoming stream of data to the other end of the buffer. As long as the buffer remains full the video will play without interruption. If the delivery slows, so that the buffer empties, then there will be an interruption in the service. Since this is an efficient way to play a long stream of video it is described as “streaming video”.

The same principle can be applied to audio, animation or a program which can start running before it is entirely delivered. Thus the general term “streaming media” is often used. This mode of operation is contrary to the standard operation of the Web which is based on the principle of sending a request for media, having the requested media delivered, and the connection between the computers is not maintained. As a result streaming media usually requires the use of plug-ins from companies such as RealNetworks (specialists in streaming audio and video, URL http://www.real.com/). Some examples of the use of different types of media which have been “streamed” are shown in the table below:

3.1.5.1.1 Audio	Since streaming technology is capable of supporting data streams of unlimited length it is possible to use it for continuous data such as radio broadcasts. Several radio stations broadcast world-wide by making their output available as streaming audio on the Web.
3.1.5.1.2 Video	Several TV stations offer video streams although more of them are up-to-date clips than live broadcasts. Some stations broadcast weather forecasts.
3.1.5.1.3 Animation	Some animated sequences can be long and complex and can even include the opportunity for interaction. When the download time would be very long these can be implemented in a streaming mode, such as that used by Macromedia Shockwave (http://www.macromedia.com)

***Case study**: Little use has yet been made of streaming media in meteorology training but an experiment in Edinburgh University showed that the amount of text presented in a Web-based training module could be almost eliminated by replacing it with streaming audio. Furthermore, more screen space could be used for graphics. Screen design was greatly altered since the removal of text meant that a lengthy series of exercises could be carried out on a single graphic (such as a satellite image) without any need to change the screen – all the instructions and feedback were given through audio. Although the experiment was successful the system was not implemented because few of the intended users were thought to have audio facilities on their computers (and individual earphones for every student).*

The delivery of audio or video to an individual when and where they want it can be efficiently achieved by streaming media. However, if the broadcast is to be made at a specific time (for example, a world-famous meteorologist is about to present a keynote paper at a conference which will be broadcast on the Internet) then delivering a separate stream of audio and video to every individual is inefficient. If the speaker is in one country and ten people in another country are viewing the broadcast then it makes sense to send the signal once over the international lines and then to split it into ten streams in the destination country. This is multicast technology which is available specifically to make efficient use of bandwidth for synchronous broadcasts.

3.1.6 Authoring tools

Let's assume that you need some CAL to teach a meteorological topic and you have searched the likely sources and found nothing that meets your needs, so you have decided to produce it yourself. Is this a sensible decision? That depends on a number of things: how much time you have; how much experience you have; how many trainees will use the software; do you have all the resources, software, data, graphics?

Most people embarking on producing CAL know for whom they are producing it and what type of computing environment they will use. However, it is worth thinking about a wider audience at an early stage to ensure that there is potential for your software to be used by many more people. Such a consideration usually leads to one of two choices, PC or platform-independent. Since PCs are very widely used, particularly in meteorology, any program that runs in a standard PC environment should be useable by a very large number of people. If the software can be made platform-independent then even more people can use it. However, it is usually possible to create more interactive software for a PC-only platform since the known characteristics of the PC can be exploited. This will change as Web-based software improves.

The next choice is how to produce the software. You can use a programming language, such as Visual Basic or C, or you can use authoring systems, such as AuthorWare or Toolbook. This is probably the single most important choice you can make which will affect the time it will take to produce the software. Authoring systems are much faster to use. Even if you are already familiar with a programming language and would have to learn how to use an authoring system it is still almost certainly worth using an authoring system.

There is probably not a great deal of difference between different authoring systems so your choice should be quite arbitrary. However, you may want to consider if you know anyone who has used one particular authoring system who could advise you if necessary.

An authoring system is designed to help you create an interactive user interface with as little effort as possible. Most also have built-in CAL properties which you can either use or adapt to your needs. In addition, they encourage the separation of the "content", your text, diagrams, video, audio, etc. from the program and user interface. This separation is vitally important to the longevity and reusability of your software.

Authoring systems which have been extensively used by other meteorologists include AuthorWare (http://www.macromedia.com/software/authorware/) and Toolbook (http://www.asymetrix.com/). These systems allow you to prepare material which can be produced and distributed on floppy disks or CD-ROMs. They are also able to convert some of their material to a form suitable for distribution on the Web.

On the other hand, you may decide that you want to produce material solely for delivery on the Web. It is easy to produce HTML files and an obvious starting point is to convert existing lecture notes and handouts. This can be useful but is not a good starting point for producing Web-based training material. CAL material, to be effective, must engage the learner in some activity other than reading. There is no point in producing material which could just as easily be in the form of a book. Books are among the most versatile of all teaching materials since you can read them when and where you want, you can read them thoroughly or just flick through, and they usually have a helpful index. What books can't do is ask you to apply what you have just learned and give you feedback on how you apply your new-found knowledge. This is what CAL should do! To do this on the Web you need to use Java and you need to have an interface which is more complex than the normal browser interface. In addition, if you start developing many Web documents, you will find that it is important that the "look and feel" is consistent. This means that images should always be designed to fit a standard browser size, fonts should be standardised, the style of headings, instructions and links should always be the same and that clicking on a link or button in one document should have the same result as clicking on identical buttons or links in other documents. Authoring systems for the Web are becoming available (see for example WebCT (http://homebrew1.cs.ubc.ca/webct/) the EuroMET Toolkit (http://www.euromet.met.ed.ac.uk/), or for a review of tools (http://www.umanitoba.ca/ip/tools/courseware/index.html)). These help overcome the "look and feel" issues by providing you with templates and they can also include useful tools to support electronic dialogue between the trainer and trainee or between trainees (see the next section).

Do not underestimate the time and effort that it takes to produce good CAL material. It is difficult to give firm guidelines because CAL can take many forms. One parameter which is sometimes used is the ratio: *number of hours the producer took to produce the software / number of hours each trainee uses it*

There are some fundamental flaws with this measure since a trainer who produces a CAL program, which effectively halves the time a trainee takes to learn a topic, will have a higher ratio than a trainer who produces a program which takes the same time as traditional methods. Nevertheless, since no adequate alternatives have been proposed let's look at some values for this ratio. For those with little or no previous experience of producing CAL it is very unlikely that a ratio of less than 300/1 can be achieved. This is assuming an efficient authoring system is used and neglecting the time taken to learn how to use the authoring system. In organizations where CAL production is a full-time job it is unlikely that anyone would claim to do better than a 50/1 ratio and 100/1 is probably more realistic.

***Case study**: EuroMET (European Meteorology Education and Training) began producing Web-based training material in 1996. At that time authoring systems for the Web barely existed and they began by producing their own authoring tools. These tools allow authors to produce interactive Web documents in a uniform style including some degree of interactivity with only basic knowledge of HTML and no knowledge of Java. These tools were used to produce about 4000 web pages which could have the "look and feel" modified after the pages were written. This allowed features to be added to the pages without the original authors doing any more work. The tools were designed for multi-lingual use and the 4000 web pages were subsequently translated from English into French, German and Spanish. An important aspect of these tools is that they include a suite of Java programs which have no specific "content" and authors can adapt them to their own individual needs. These tools are public domain (EuroMET Toolkit) and freely available.*

3.1.7 Video-conferencing and other forms of electronic communication

In a situation where the trainer and trainees are in the same place at the same time several different types of learning activity are carried out and one activity blends into another almost imperceptibly. Some such activities (Laurillard, 1993) include:

Discursion: Trainer discourses on the knowledge to be gained and the trainees discourse on their understanding of the concepts.

Adaptation: Trainer adapts teaching in the light of the trainee's discourse

Interaction: Trainee's act to practice their knowledge

Feedback: Trainer gives feedback both at the level of specific actions and at the level of general understanding of the concepts.

These activities are all part of normal training whether it is conducted in a classroom or at a distance. If the trainee is working alone at a computer it is necessary to provide appropriate communication to allow feedback to influence the trainee and to allow the trainee's discourse to influence the trainer's adaptation of the training.

Electronic communication exists in many different forms. These forms can be split into synchronous communication and asynchronous communications. The difference is the difference between speaking to someone on the telephone and leaving a message on their answering machine.

A summary of the common forms of electronic communication is given below:

Asynchronous	**The people communicating do not need to be working at the same time. Any message passed by one can be read by the other at a convenient later time.**	
	Description	***Examples of use***
Email	The most common form of computer-based communication is email. Virtually all computers support email allowing the medium to be independent of the type of computer. In most cases, documents (reports, images, spreadsheets, etc) can be attached to the email messages. A single message can be sent simultaneously to a list of people.	Trainers can send course information to an entire class with a single message but can also communicate with individual trainees to answer questions or comment on submitted reports.
Discussion groups	Discussion groups developed from the earlier Bulletin Boards used on Internet. They provide a forum for many people to contribute to a discussion topic. The threads of the different aspects of the discussion are kept separate automatically. This allows someone to follow the thread of an argument long after the discussion itself took place. Discussion groups are usually created on the Web and can be limited to a small, selected group or thrown open to the whole world. Although anyone with access can contribute to a discussion group, the trainer is able to remove spurious or out-of-date messages.	Questions asked through a discussion group may be answered by a teacher or by fellow trainees. The discussions may become lengthy and involve a great deal of comment and counter-comment with contributions from several people. Significant discussions which reveal important concepts and highlight potential misunderstandings can be kept from one course to another so that trainees can benefit from the lessons learned by their predecessors. It is common to start a discussion group with a simulated discussion to avoid trainee's inhibitions about being the first to contribute. Discussions can follow in the tradition of Socratic dialogue through which a teacher can gradually enlighten a student.

Newsgroups	Newsgroups are similar to discussion groups but are not under the control of individual trainers. In most cases they are international and devoted to a single topic. One such newsgroup is *sci.geo.meteorology*. There are many *sci* groups devoted to various branches of science and there are several *sci.geo* groups devoted to geophysical science subjects, but there is only one *sci.geo.meteorology* and anyone in the world can submit messages to it which will be seen by everyone who subscribes to the newsgroup. There are many thousands of newsgroups on a huge variety of topics.	The most common use of a newsgroup is to seek information. It is reasonable to assume that the people who subscribe to a newsgroup are those around the world most keenly interested in that subject. A novice can send a question to the group and someone knowledgeable will probably answer it, perhaps there will be many answers – some conflicting. The key aspect of these newsgroups is that questions can be asked of groups of experts without having to know who or where the experts are. Of course, some questions are asked time and time again. Most newsgroups maintain an FAQ, or "frequently asked questions" list and the associated answers. The FAQs for most newsgroups are available at http://www.cis.ohio-state.edu/hypertext/faq/usenet/top.html

Synchronous	**All participants must be using their computers at the same time.**	
	Description	Examples of use
Chat	Chat is a text-based communications medium which depends on everyone using the same software at the same time. This is often achieved by everyone "going to" a specific location on the Web, sometimes called a "chat room". Messages are typed and relayed immediately to everyone else in the chat. It can be used to hold meetings or tutorials among a widely dispersed group of people. The messages can be logged automatically to form "minutes" of the meeting.	Chat is an ideal way to hold a tutorial among a group of people who cannot be in the same location. It is easy to carry out a discussion because there is virtually no delay between someone typing a message in one place and the message being seen by everyone taking part (time delays are typically less than 2 seconds for trans-Atlantic meetings). Meetings held using chat systems are also useful for planning research projects.
Audio-conferencing	The telephone is an tool and everyone knows how useful it is. The main advantage of Web-based audio-conferencing is that the internet connection is usually charged at local telephone rates but the conference can be to anywhere in the world. The main disadvantage is that the audio quality is not quite as good as telephone quality.	Telephones are commonly used to support distant learners. Open Universities usually assign telephone tutors for remote students. Audio-conferencing can be used in the same way but it does depend on both the student and the tutor using their computer at the same time.
Video-conferencing (desktop)	Video-conferencing is to audio-conferencing what the video-telephone is to the normal audio telephone. It allows the people participating in a conversation to see each other and therefore to express emotions visually and to use visual cues which are unavailable through audio alone. Although compression techniques are improving all the time, the quality of video-conferencing is poor unless a guaranteed, and usually substantial, bandwidth is available.	Desktop video conferencing allows someone sitting at one computer to talk to and see someone at another distant computer. It is useful as a method of calling up expert help. A tutor can be available "on call" to handle requests from trainees if required. The quality of desktop video conferencing is such that it currently has little benefit over audio conferencing. Since desktop video conferences are usually point-to-point and therefore only involve two people they are not suited to teaching large groups.

Video-conferencing (studio-based)	Studio-based video-conferencing differs from desktop video conferencing through a significant investment in facilities. Most video conference studios have good lighting and sound systems, space for a small group of people, and a high bandwidth connection to remote sites which makes the quality much better than desktop video conferencing. Some studios also have facilities for showing pictures and objects through a "visualiser", a TV camera situated above a well-lit, flat base. An important aspect of a studio video conference is that it can often involve multiple groups. In this situation it is common for the video signal to be conveyed from the site which is the most recent source of continuous speech. With automatic switching this leads to a natural conversation similar to that seen on TV. This can be further enhanced by allowing fully-mixed audio; everyone can speak at the same time and everyone will hear comments from all sites.	High quality video conferencing makes it possible to teach several groups at a distance simultaneously. In Scotland all universities are connected together through a series of Metropolitan Area Networks (MANs) with a bandwidth of 155 Mb/s. This permits video conferences with TV quality video and CD quality audio. The system has been used for teaching in several different subjects such as remote sensing and medicine. It is particularly useful when there are a few trainees at several widely dispersed sites and there may be only one or two very expert teachers. In this case trainees can have discussions with expert teachers they would not otherwise be able to meet. Although the Scottish MANs network is a dedicated network it also connects to ISDN networks so discussions can include contributors from anywhere in the world with ISDN telephone connections.
Electronic Whiteboard	Seeing and hearing a trainer is important for a distant trainee but sometimes it is more important to view a graph or even to interact with a graph and add to it. This is the purpose of an electronic whiteboard. It can be used in the same way as a conventional whiteboard but the white rectangular area is simultaneously shown on the computer screen of every participant and as soon as one person draws on it everyone else sees what is drawn. It is also possible to place pre-prepared diagrams on the whiteboard so that it can be used like an overhead projector.	A useful meteorological applications of an electronic whiteboard would be for a trainer to place a chart or image on the whiteboard and ask the trainee at the remote site to identify features. One example might be that a satellite image could be shown and the trainee could be asked to draw a line showing the location of a front or to encircle an area of deep cumulus convection. The trainer can see what the trainee draws and can modify it to show the trainee how to improve the analysis. Clearly this requires another channel of communication – usually audio-conferencing or desktop video-conferencing.
Shared applications	Shared applications take the idea of sharing a working space (such as a whiteboard) to a much more useful level. A computer application can be selected on the trainer's computer and a number of trainees at distant sites can be invited to share it. Once sharing is established everything the instructor does with the computer application is shown on the trainees' screens. This is an ideal way to show people how to use a new computer package. It is further enhanced when used in a collaborative mode where the instructor can pass control to any one of the distant trainees who can then work with the package and everyone can see the results. This system works even if the trainer's computer is the only one with the application to be shared.	Imagine a situation where a new computer package for processing satellite images is installed at all forecast stations. It may be expensive or impractical to call all forecasters to a central location for training. Using shared applications across a computer network an instructor can demonstrate the use of the package and ask several of the forecasters to use it in turn. After this initial introduction some forecasters might still have problems with the package and need to ask questions. Traditionally this might be achieved by the forecaster telephoning the instructor and being "talked through" the process, but with a shared application the instructor can take control of the forecaster's workstation and show how it should be used then watch what the forecaster does to check for mistakes. Shared applications need an additional form of communication which is usually either audio-conferencing or the telephone.

With the exception of studio-based video-conferencing, the common Web browsers support all of the above facilities. This means it is unnecessary to install specialist software, but it also means that there is a very high probability that the remote site with which you plan to communicate is using exactly compatible software.

***Case study**: A lecturer in Edinburgh University planned to give a series of lectures in remote sensing to a group of students in another Scottish university. He could travel to the other university but decided to use studio-based video-conferencing instead. When teachers at three other universities heard that the lectures were to be available on the video conference network they arranged for their students to attend as well. The lectures were made available simultaneously to students in four different universities. Remote sensing is a subject in which images are important and difficult topics need complex graphs to be constructed incrementally during a lecture. In addition to the video-conference communication the lecturer arranged for each site to have a computer and projector so that a shared application could be used and seen by all students. The lecturer prepared all the material using Microsoft PowerPoint and shared this application during the lectures. Since the shared application was additional to the video channel all sites remained in visible and audible contact while also having access to the computer presentation. The fully-mixed audio system was used by the lecturer to ask questions of students at remote sites and allowed the other remote sites to hear the dialogue and see the speakers.*

3.1.8 Peripheral hardware

In the section on common software packages there was some discussion of resource sharing and re-use. Some of these resources might be text, created as part of lecture notes or presentations, but many more are images and occasionally video or audio. In order to use educational technology effectively it is necessary to be able to acquire, store and distribute these different types of media.

3.1.8.1 Image and graph capture

Images and graphs are quite different objects. The word “picture” is sometimes, confusingly, used to mean either. Images are raster-based. That is, they are composed of row after row of dots or picture elements (pixels). Graphs, on the other hand are usually composed of connecting lines between a few points whose coordinates are known. The most common devices for capturing images are scanners (usually flat-bed scanners capable of taking a whole sheet of paper) or digital cameras. These devices can also be used for capturing graphs but the result is that the graph is no longer a true graph but an image of a graph.

Flat-bed scanners are high-resolution devices capable of scanning pages in full colour at resolutions up to 600 dots per inch. In practice, such high resolutions are required only if the image is to be used in a high quality printed publication using a printer with a similar resolution. Since screen resolutions of 800x600 or 1024x768 are most common it would be possible to fill a screen with a picture which was between one and two inches across if the highest resolution of a scanner was used. When images are intended for use on a screen or for printing on an ink jet or laser printer a scanner resolution of 150 to 300 dots per inch is perfectly adequate and sometimes even 75 dots per inch is sufficient. Scanners are an extremely simple and efficient way to capture images. The only aspect of scanning which requires care is placing the image on the glass of the scanner. If the image edge is not parallel to the edge of the glass it is very difficult to rectify the skewed image after scanning.

It is common when buying a flat-bed scanner to find that OCR software (optical character recognition) is included. This allows page after page of text to be scanned and the software turns the “pictures” of text into genuine text by attempting to recognize the characters. This type of software does a remarkable job since it copes with a wide range of font sizes and styles.

However, it does make mistakes. Error rates are sometimes quoted as being less than 99.9%. This seems very reliable until you realize that this page contains nearly 3000 characters so an error rate of 99.9% implies that there would probably be three errors on this page if it was scanned and converted to text using OCR software. While such devices are useful they should be used with caution and carefully checked!

Digital cameras are available in a range of prices and qualities. They are as easy to use as normal compact cameras. They can usually be used in slightly lower light conditions than normal cameras. They contain no film but capture the image on a CCD (charged coupled device) in the same way as a video camera. This digital image is then saved in memory within the camera. The size and number of images stored in the camera depend on its memory and hence on its cost. Storing up to 64 images at 640x480 resolution is common. It is advisable to select a camera which allows a higher resolution than you might often use. This is because digital cameras do not always have a zoom lens and so it is sometimes difficult to “frame” the image exactly as you might like. It is then necessary to crop the image digitally once it has been downloaded into the computer. After the images are downloaded, the camera memory can be cleared ready for further use.

The only capture devices suitable for handling graphs accurately are digitising tablets, which allow you to trace the lines and identify coordinates. These devices are now regarded as very specialist and not in common use. A simpler approach is to scan a graph and load the image into a software package that supports both images and line drawing. The graph can then be traced and the scanned image deleted. This allows the graph to be captured in a form which still allows it to be edited, for example, to stretch one axis or re-label it with different text.

3.1.8.2 Video capture

Video has been used as an educational technology for many years. Most trainers will have a set of favorite videos of meteorological phenomena that they show regularly. Digital video can be used in a similar way as part of an illustration within a computer based training application. However, digital video has a number of advantages: it can easily be replayed or stepped through one frame at a time or even played backwards; it can be edited to ensure that only the directly relevant clip need be viewed; it can be mixed with other media such as text or graphics to enhance the illustration.

Capturing video in digital form is now relatively simple. A wide range of video capture cards exist which are both inexpensive and easy to use. A video capture card fits inside a computer and takes the signal from a video camera or recorder as input. Care must be taken when selecting a system to ensure that it will produce results of the desired quality. Some of the factors which must be considered are the frame size and the frame rate. Less expensive systems will usually capture smaller images and may drop some frames. It is also sometimes possible to capture still images from video. Most video capture systems will save the video sequence in AVI (audio-video interleaved) format, a Microsoft standard. While this format can be played on many different platforms, other formats are also in common use. Quicktime is an Apple format which is also used on PCs. MPEG (Motion Picture Expert Group) is an ISO standard format for video and is capable of producing almost TV quality at full screen resolution on MPC3 computers, which have built-in hardware support for MPEG decoding.

While MPEG is probably the most desirable format to use it is also the most difficult to capture. Since MPEG video is highly compressed it requires a considerable amount of computation to capture video in real-time. MPEG capture systems are therefore more expensive than the more common AVI systems. High quality MPEG capture can be carried out by bureau services.

Whatever form of video capture is selected it is also essential to have software to support video editing. This will allow you to join one video sequence to another, add graphics to the sequence or add a sound track. Many video capture systems will come with editing software, such as Adobe Premiere, included.

3.1.8.3 Audio capture

It would be reasonable to assume that audio capture would be simpler than video capture. After all, multimedia PCs all come equipped with an audio system, which includes a microphone and the ability to record sounds. However, it is almost impossible to record audio of a suitable quality without the use of a recording studio. The main problem with recording audio close to a computer is that the microphone picks up the fan noise from the computer. It is essential that the microphone is removed some distance from the computer and it is best in a sound-proof booth. Once the audio signal is recorded it will probably require editing. It may be necessary to mix one audio source with another or to mix it with music. At this stage it usually becomes clear that the editing software which is included with multimedia PCs is very limited in scope and a commercial audio editor is required.

The use of audio in computer-based training applications can make them much more enjoyable and effective and can also encourage longer use as a result of reducing the amount of on-screen text. However, everyone is used to a high level of professionally produced audio material through radio and television and tolerance of poor quality material will be low.

3.1.8.4 Distribution: making your own CDs

When is it more effective to send data or programs using CD rather than floppy disk? Now that we can assume that there are no institutions unable to read a CD it is purely a matter of which costs less. If you already own a CD Writer then it is as cheap to produce a CD as two floppy disks. Therefore it is cheaper to use a CD for all volumes of data from 3 Mbytes up to the CD capacity of 650 Mbytes. Of course, you may not already own a CD Writer. The cost of these devices is dropping rapidly and they are now well within the price-range of any group which sends information in a computer-compatible form regularly. CD Writers are also very useful for storing information in a secure (read-only) form while keeping it readily accessible. It is much more effective as an archive medium than tape if the archive is regularly accessed.

Advice on choosing a CD Writer cannot be given here because the available options are changing too rapidly. You should assume, however, that you would use a CD Writer much more frequently than you originally planned once its many uses become obvious. If you plan to produce multiple copies of some CDs it is important to buy a CD Writer which can write at faster than normal speed such as x4 or x8. At normal speed, a CD Writer would take 74 minutes to produce a full CD. The reason that CD Writers do not appear to be as fast as CD players (commonly up to x24) is that when a CD is being written it is essential that data should continue to be delivered to the CD Writer continuously. If there is even a momentary delay the CD production will fail. Use of a fast CD Writer is only possible if the data can be delivered continuously by the hard disk and data bus of the computer.

***Case study**: In 1992 a few meteorologists were sitting around a table in Boulder, USA. They were attending the 1st International Conference on Computer Aided Learning in Meteorology. They were discussing how nice it would be if there was a pool of graphical resources, pictures of clouds, satellite images, weather maps, common diagrams, which could be shared among all meteorology trainers and which could be used without worrying about breaking copyright laws. The idea was born for a CD-ROM which was eventually produced by asking many meteorologists around the world to submit images, on condition that they could be used for non-profit-making education and training. More than 1300 images were submitted and the “Images of Meteorology” CD-ROM was produced. This was only possible by using digital technology. None of the images was submitted on paper, as photographs or 35mm slides. Many images, which started in these forms, were digitized using the Kodak Photo-CD system available through most photographic shops. Other images were already in digital form and were submitted by using FTP. A total of 1000 CD-ROMs were produced and distributed within the meteorological community.*

3.2 Criteria for using educational technology

Technology is a tool to help to train meteorologists just as an overhead projector is a tool. It must be used at the right time, in the right place and in the right context. In this section we consider what should drive a move towards increasing use of educational technology.

3.2.1 Educational effectiveness

Educational effectiveness is the key factor in deciding whether it is right to use educational technology. We need to ask several questions:

- Can we train a particular topic better by using technology?
- Are there types of training which are impossible without using technology?
- Can we use technology to make the training better match the needs of the trainee?

and last, but certainly not least:

- How can we measure the effectiveness of the training?

This last question is addressed in the Chapter on Evaluation in Part II of this text (see also Oliver and Conole, 1998), so we will concentrate on the first three which all relate to the quality of training. Technology is used effectively when it improves the quality of the training experienced by the trainee. This improved quality may be perceived as:

- fewer trainees with misconceptions – *better understanding*
- more rapid understanding of concepts – *faster understanding*
- greater understanding of the link between theory and practice – *practical understanding*

Meteorology is a visual subject and makes use of maps, satellite images and other diagrams. Frequently, a better understanding of what is happening in the atmosphere results from observing how it changes with time. Showing the development of case studies through animated diagrams or images is very much easier using computers than by other means.

Another special attribute of meteorology is its use of models: both conceptual and numerical. If these models represent the atmosphere, or some component of its behavior, accurately then a great deal can be learned by adjusting the models to investigate their sensitivity to changes. One example might be a simple model of convection through which a trainee might experiment by adjusting the maximum daytime temperature or the stability of various atmospheric layers. A good simulation of this sort could be coupled to video sequences showing different depths of cumulus convection corresponding to the extent of the instability.

Bloom (1956) developed a description of levels of thinking that can be used as a template for activities intended to promote these different thinking levels. The following table lists Bloom's thinking levels with a meteorological example (mid-latitude depressions) and a few styles of activity which promote learning to the required level.

Bloom's levels of thinking	Meteorological example	Computer-based activity
Knowledge of concepts and principles	Surface pressure reduction is produced by net divergence aloft.	Animated diagram showing convergence and divergence but with overall net divergence. Better still would be to allow the learner to control the amount of convergence and divergence and show the resulting surface pressure change.
Comprehension of implications and uses	Surface low pressure centres are likely to develop ahead of upper troughs.	Learner should be able to identify regions of likely development on several upper air charts. Feedback can be given for incorrect answers pointing out why they are incorrect. When the correct answer is given the feedback could include the subsequent MSL chart showing the low centre.
Application of theory and problem solving	Height fields and winds are related to where regions of warm and cold advection lie. Deduce this relationship.	Offer 500 hPa and 1000 hPa charts and the ability to take the difference between them. Wind speed and direction can be shown at specific locations when clicked.
Analysis: distinguishing fact from inference and evaluating relevance	Use understanding of surface pressure changes to make deductions about the life cycle of a depression through the evolving relationship between changes in surface pressure, advection of warm and cold air, and movement of the upper trough.	Provide access to a variety of charts over several days in a computer capable of overlaying charts and taking differences between fields. Objective is to prepare a short illustrated report.
Synthesis: build relationships from theory and observation	Determine the key concepts need to describe development in mid-latitude depressions.	Using a variety of different sources (books, programs, research papers, the WWW, case studies) extract the relevant information and relationships and present a short talk or prepare a web page.
Evaluation: prioritize, classify, diagnose	Relate vorticity, divergence and thermal advection views of a developing depression to the potential vorticity view of the same system.	Provide an equation manipulator and access to data from a model assimilation. The equation manipulator allows the learner to build terms found in the dynamical equations one by one, or in combination, and applies them to the model fields to see the distribution of each term or combination. Output should be a report assessing the relative merits of the potential vorticity view of development.

3.2.2 Cost effectiveness

The most common argument for using educational technology is that it is cost effective. This argument is usually used by those who have little experience of using educational technology and is almost never used by those who have been involved in producing good quality computer-based material. At its simplest the argument says – once a computer program can teach someone how to do something it can be used over and over again, in many countries, year after year at no additional costs, thus saving enormously on expensive teachers. This ignores two fundamental aspects of educational technology: first, it is costly to produce good computer-based material and second, using educational technology does not remove the need for a human trainer.

A very detailed analysis of the factors involved in calculating cost effectiveness in open and distance education, and its comparison with traditional methods is given by Rumble (1997). It is clear that there will be no cost-benefit in producing computer-based material for very small numbers of trainees and that it will be of greater benefit, in terms of cost per trainee, the larger the number of trainees. We can make a qualitative comparison of computer-based and traditional classroom-based training.

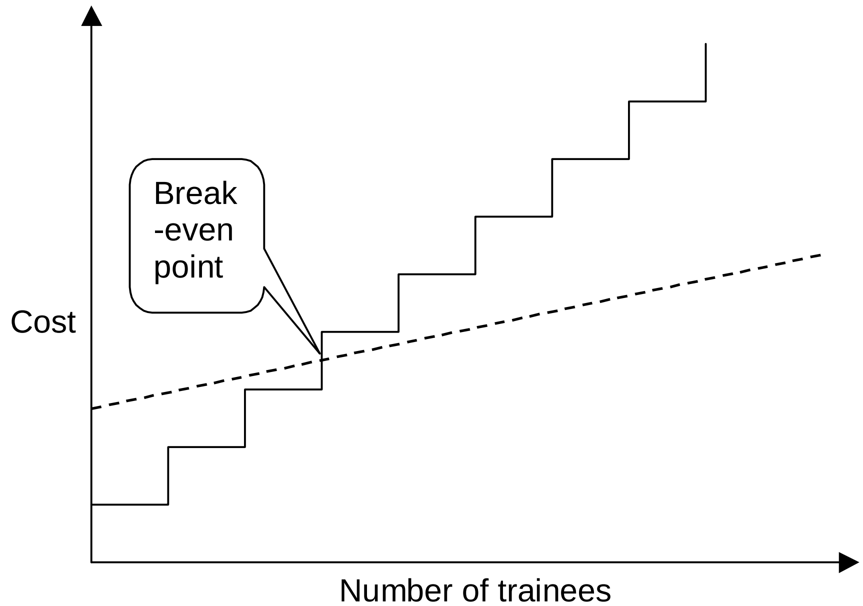

Figure 3-4: Cost of training with increasing numbers of trainees for classroom teaching (stepped line) and open/distance learning (dashed line).

In the diagram above the stepped line represents the cost of training a group in a classroom. The cost of providing the teacher, the classroom, and the audio-visual equipment is approximately constant for a small class or a large class up to the capacity of the classroom. The group of trainees may be much larger than will fit in to one classroom, perhaps through simple volume of numbers, or because they are in different locations, or because they come to take a course at different times of year. In each of these cases there is an increment in the cost each time the course must be run so the cost increases in discrete steps as more people are trained.

In the case of computer-based training the initial start-up costs are higher as a result of the production effort needed before a single person is trained. Once the material is produced the costs are primarily the provision of the software and the support of a teacher when needed. It is assumed that computers are already available to the trainees. If this is not the case then the slope of the increasing cost per trainee will be steeper. It is also assumed that the support effort of the teacher is less than in a classroom setting because the trainees are spending more of their time using the computers. There will be some point below which the high start-up costs of computer-based methods are not worthwhile and above which computer-based methods have an increasing cost-benefit. This is the break-even point. It is not possible to determine the breakeven point without a detailed analysis of the costs involved in each individual institution. A detailed analysis would need to include factors such as:

- the cost of training for preparation as well as delivery of training
- the infrastructure costs of a training establishment (in terms of both accommodation and provision of services such as secretarial and catering support)

- dependency on any external resources (e.g. public libraries, public-domain software)
- costs of travel and accommodation for trainees, compared with on-the-job, open learning
- cost of replacement staff if trainees have to leave their normal place of work
- cost of computers and audio-visual equipment including expected lifetimes and replacement costs
- salary costs of support staff for technical and computing equipment
- cost of network connections if used for distance learning
- cost of production of computer-based materials
- cost of training for training staff, particularly for educational technology
- penalty for lack of training while waiting for a suitable course, compared with constantly available, just-in-time training

A methodology for studying the economics of distance education particularly using educational technology has been produced by UNESCO (UNESCO, 1977, 1980 and Eicher et al 1982)

In hard economic terms, few countries have large enough numbers of trainees to justify a dedicated, computer-based training infrastructure. However, through international cooperation it is easily possible for several training establishments to share their resources and efforts and thus benefit by receiving much more than each has to contribute. Informal cooperation can be effective but organized cooperation, through which common training needs can be established, and strategies for meeting these needs can be agreed, is even more effective.

Another aspect of the cost effectiveness of training organizations is the comparison between institutions which run centralized training schools, often with a residential environment, and those which choose an open and distance training approach using on-the-job training. Laidlaw and Lalyard (1974) in a comparison of traditional universities and the UK Open University studied the ratio of fixed costs (buildings, permanent staff, etc.) to costs which vary with the number of students (course materials, student support staff, etc.) and found for open and distance learning courses that the fixed:variable ratio was 2000:1 while for campus-based courses it was 8:1. This again reflects the high start-up costs of open and distance learning.

3.2.3 Availability

As the world-wide pool of computer-based training material expands it becomes much easier for institutions to embark on using educational technology. Sharing and re-using these resources is an essential part of using educational technology. This also increases cooperation between different meteorological training institutions.

A trainer planning a course will follow a process described in detail in chapter 2. At some stage the trainer will gather together the necessary resources. One such resource might be a suitable textbook. This choice can be made by looking at publisher's catalogues or visiting bookshops. In either case there is a wealth of available material. The trainer can select examples which match the learning objectives of the course as closely as possible. Compare this with the gathering of computer-based material. The first problem is that there is no obvious source like publishers or bookshops. The second problem is that no one could describe the available resources as a "wealth" of computer-based applications – there is still a limited choice. A third problem arises in how computer-based material is used. With a book you can easily say "Skip chapters 3 and 4 as we are not covering that material in this course", but many computer-based applications come complete and you cannot pick and choose the parts you want. For this reason the computer-based applications which are most widely used around the world are often those which are quite small and can be adapted to be used in several different types of training courses.

In place of bookshops and publishers the trainer usually turns to the Web to find computer-based resources. Fortunately there are many search engines available which, through appropriate keywords, should identify any available applications. Within the meteorological training community the CAL Working Group of SCHOTI runs a web site (http://www.met.ed.ac.uk/calmet) which is one starting point for those searching for computer-based training applications. In addition, the Education and Training Division at WMO maintains a list of available items and a Virtual Training Library (http://www.wmo.ch/web/etr/vtl.html)

The problem of lack of choice is one that is changing rapidly. There are now quite a number of groups around the world producing computer-based training material for meteorology and they recognize that duplication of effort is not necessarily a waste of effort but a source of a variety of material from which other trainers can select what suits their own needs.

The problem of having to accept entire computer applications even if you only need part of them is solved by breaking the material into a more modular or granular form so that a particular module or grain can be chosen rather than the whole course. The usability of these small applications is further enhanced if the content is separated from the way the program works in such a way that each trainer can modify the content for their own local needs and the program will operate with that new content. One extreme case is a "content-free" application, such as a multiple choice quiz program where the trainer creates the questions and answers for the quiz. An intermediate case might be a satellite image analysis application where the program can present images and comments and ask for locations on the image to be identified but the trainer can arrange which image, comments and tasks should be used.

Yet another problem which can arise with textbooks as well as computer applications is that the material may be available but not in the appropriate language. While translation of a textbook is a major task it is generally simpler for a computer application. Well-constructed computer applications, where the content is separated from the design and actions, make translation from one language to another relatively easy.

3.3 Institutional issues related to educational technology

The decision to use educational technology on a training course often originates with an enthusiastic trainer. It is vitally important that institutional issues related to using technology in training are addressed at an early stage or the training may fail for reasons which have nothing to do with the quality of the trainer or the computer-based material.

3.3.1 Management issues

The support of senior management is essential if educational technology is to be introduced successfully into courses. There are many reasons for this; mostly to do with management of shared resources but also concerning setting of priorities. Some of the main points are:

Access to computers	There is no point in running a course for 30 trainees if there is only one computer available. The use of educational technology requires access to computers. In most cases these will be a shared resource so that the computers will be used for different purposes at different times. Use of computers by trainees must not be seen as a marginal activity. It is essential that computers be available, not only during organised class periods, but also during "study time" when trainees can work on their own, at their own pace. Sometimes this requires access to computers in the evenings or at weekends. Doubling the hours in which access is possible can often double the apparent number of computers. This can be much cheaper than buying more computers. Before building educational technology into a course it is necessary to estimate the number of hours each trainee will require computer access (taking into account private study), multiply this by the number of trainees and ensure that the required number of computer-access hours is available. Where several courses are competing for the same computers it is the responsibility of senior management to ensure that the total demand is satisfied.
Computer support	A computer is only useful when it can do what the trainee requires. It can fail in a variety of ways: necessary software missing or incorrect version; hardware faults such as mouse, keyboard or disk errors; network connections unavailable or network speed too slow. Failures such as these are equivalent to the trainer not turning up to give a lecture – they are unacceptable to trainees. Senior management must recognize that the equipment for educational technology must be kept in working order with a very high priority and allocate support staff accordingly.
Accreditation	Training gained through the use of educational technology must be accepted in the same way as any other type of training. It should not be considered as an optional extra because trainees will recognise that it is given little value and will not regard it as important. In many types of meteorological training the learning objective is to reach a level of competence in certain tasks; this lends itself to a computer-based approach which allows repetition of the tasks and can measure the degree of competency.
Trainer credit	When a trainer uses a technological approach on a course they often spend less time lecturing and more time preparing computer-based material. This is often given less credit, as the trainers are not seen to be actively teaching. In fact, the trainers may be making much better use of a smaller number of contact hours and having a more profound influence on the time trainees spend in private study. The end result should be more effective training and the trainers should be given credit for the preparatory work which is inevitably more demanding than conventional training.
Control of source material	Most institutions want to ensure that they have full control over all the training material their trainees use. This means that they want the right to use it in different ways, to modify it and to have it upgraded appropriately. If they are using software for which a license fee is required they need to know the conditions of the license and the maintenance rights it provides. If software has an associated annual maintenance fee it needs to be included in cost estimates for the course. In short, senior management needs to be able to determine that it has the right to use computer-based material and, where fees are applicable, be able to control the expenditure.
Training policy	Probably the single most important management issue is to have an established training policy. This will normally require foundation training to be taken when someone starts a new job and for continuation training to be taken at various stages in their career. However, if open and distance learning is to be used for any components of the training strategy that should be specified in the policy and given appropriate importance. On-the-job training can too easily be regarded as something which will done in "available free time". This is unworkable; distance training should be given time allocation and learner support in the same way as conventional training.

3.3.2 Infrastructure issues

In order to use computers as a means of delivering training it is essential to have the same software on every computer used by each trainee. If network technology is to be used to provide tutorial support to the trainees it is equally essential that all computers can support the necessary communications strategy.

In the following table the various technological ways of delivering both training and support are considered:

	Training delivery	**Learner support**
Floppy disk or CD-ROM	Training software can be produced on floppy disk and installed on any machine or sent by post to distant learners. Since most multimedia programs would require many floppy disks it is more useful to use CD-ROM as most computers now have the capability of using CD-ROMs. CD-ROMs also have the benefit of being "read-only" media so the distributed material cannot be accidentally deleted or modified. The biggest drawback of this method is that any changes to the material require a new version to be produced, which can be costly if many disks or CDs have to be distributed. When new versions are distributed it could be difficult to control their installation so different trainees can be using different versions.	When the distribution medium for the training is by post it is also possible to support the learner by post. This is like a traditional correspondence course. In most meteorological institutions this is not used because a more immediate strategy is to have a local human tutor. In a training centre there may be a tutor regularly available. If the learners are at a remote location they may have a more experienced meteorologist nominated as a "mentor" to give them support. In cases where neither of these options is possible it is likely that telephone support would be used.
Internal computer network	Installing software onto many computers from disk or CD-ROM can be very tedious. A much better option is to install the training material only once onto the server of a computer network. This has the added advantage of ensuring that everyone using that server is using the same version of the software. However, it is still possible that internal networks in several different locations may be using different versions. Most internal networks are limited to a building or an institution.	When learners are using networked computers they have the additional capability of using email as a communications medium to contact tutors using the same network. If suitable hardware exists they could even use audio or video conferencing. Of course these modes of communication are in addition to those mentioned above.

Intranet	An intranet is an internal network within an organization. It differs from the internal networks mentioned above in that it can span several departmental networks to give a single institutional system. Thus training material provided on a server on an intranet will act as a single source for an entire organization, thus ensuring everyone uses the same version of the software even if they are using separate networks within the institution. The existence of only one source means that producing updates is very simple and can be carried out frequently.	An intranet uses the same protocols as the Internet but restricts them to within an organization. There will be a Web server within the organization accessible by everyone with a right to use it but excluding everyone outside the organization. Since the server uses the same communications protocols as Internet the same communications methods are possible. In addition to email and discussion groups, web-based synchronous chat is also available. These chat systems can be used for meetings or tutorials where many of the participants are remote. As well as audio and video conferencing, support also exists for shared whiteboards and shared applications.
Internet	There is little difference between delivering training by intranet and internet. For those who require very tight security or those who have a good internal network but poor external connections, an intranet is the best approach. The main advantage of using internet is that it provides access to training material which can be shared among various institutions. The remote providers then keep this material up-to-date. Mirror sites can be arranged to remove dependence on single servers.	Internet provides the same communications facilities as intranet. It has the advantage that it can reach more remote people allowing a training course to be run remotely for several countries at once. This also means that the trainees have access to tutors outside their own organization. On the negative side, most organizations have a lower bandwidth connection to internet than they have to their own intranet so the download times are greater. Some sites operate a firewall so that communication between the intranet and internet is limited,

3.3.3 Evaluation

Evaluation of training is so important that a chapter is dedicated to it in Part II of this book. This section considers some special issues related to computer-based material.

Two types of evaluation are generally recognized, formative and summative. The former is used during the formative stages of the learning material to gain feedback early enough to influence the final system. Summative evaluation is used to assess the sum total of the training and its effectiveness in terms of the learning outcomes. We will concentrate here on formative evaluation of computer-based material.

One of the main objectives of formative evaluation is to test the usability of the product. The way a training application appears on screen can greatly influence how it is used and ultimately whether or not it can achieve its educational objectives. Usability problems identified at an early stage prevent a great deal of wasted time later. Methods of assessing usability of web-based material have been widely researched (Riel and Harasim (1994), Boling and Frick (1997), Bevan (1997), Ravitz (1997), Nichols (1997)) perhaps because it can be easy for learners to become lost in “hyperspace”.

Usability needs to test if users can:

- understand the purpose of the program
- identify what to do to achieve various tasks (search a glossary, find a file)

- appreciate the context and the relationship between one part of the material and another
- anticipate the result of actions such as clicking on buttons

Testing for these requires a group of “test learners” who resemble the intended trainees as much as possible in terms of experience of computers and background subject knowledge. In addition, tests should be carried out in an environment as close as possible to normal working conditions. In particular, if working in pairs or groups is expected, that should be tested. Some of the methods used for the formative evaluation can include:

- Observation: This can be achieved through watching directly or through making a video of the use of the system.
- Talk-through: "Test learners" should say aloud what they are thinking so that evaluators do not have to guess their thought from their actions, perhaps wrongly.
- Interviews: Detailed debriefing after the test. It is important not to limit assessment to questionnaires, as some answers will require more in-depth, follow-up questions.

Computer-based material is also capable of capturing some of the learner’s actions. It can be designed to track the path a learner takes through a program, or to store the words which are most often used when searching help information, or to record that a learner started a topic but didn’t complete it. These factors can all help in the evaluation process.

3.4 Questions for thought

This chapter has covered the use of educational technology in general but in any organization there are particular factors which affect how it might be used. The following questions are for you to consider in your own institution. Answering them in writing might give you a personal strategy for your future use of educational technology.

- *If you have already used educational technology as part of a course (as a trainee) what did you think of it? Do you remember what it taught you any differently than other parts of the same course? If so, why?*
- *If you have used educational technology as a trainer, what was your trainees’ reaction? What did you do to measure the effectiveness of your training? Did this evaluation direct you to a change of strategy?*
- *Think of a course you are about to teach. Could you teach it without giving any lectures? If you can devise a plan for teaching this course without lectures, what would be the reaction of your managers if you suggested it? How should you react to their reaction?*
- *If you have not used educational technology as a trainer (or perhaps even if you have) try making two lists – one giving reasons why you should and one giving reasons why you shouldn’t use educational technology. Which list is more convincing?*
- *Try making these two lists from the point of view of one of your trainees, or even ask a few trainees to do it. How do the trainees’ lists differ from the trainer’s lists?*
- *What aspects of training in your institution are least satisfactory? Could the adoption of educational technology make them better?*
- *Do you teach any of your trainees through distance learning? If so, list the advantages and disadvantages for those trainees. If not try listing the advantages and disadvantages for your organization in adopting a distance learning strategy.*

- *Think of three people in your organization (trainers or managers). One of them should be the most anti-technology person, one should be the most pro-technology person and one should be neutral but considering using educational technology. Write down the arguments the anti- and pro- people would use to try to convince the neutral to adopt their view. Which are the most convincing arguments?*

3.5 Glossary of terms used in the chapter

asynchronous: a form of communication which does not require people to be available at the same time, for example, communicating by letter or email.

ATM: **A**synchronous **T**ransfer **M**ode, a computer network communications protocol.

audio-conferencing: communication using speech, usually through computer networks, possibly involving more than two people.

authoring tools: tools which ease the task of producing CAL material.

AVI: **A**udio **V**ideo **I**nterleaved, a computer-based digital video format.

bandwidth: the available data transmission rate in a computer network

browser: a program which allows someone to explore the World Wide Web.

CAL: **C**omputer-**A**ided-**L**earning. Used here as a general term which covers computer-based-training, computer-assisted-instruction or computer-mediated-learning.

CALMet: **C**omputer **A**ided **L**earning in **Met**eorology

CD-R: Recordable version of CD-ROM. It is possible to use these discs in a special drive to write a CD-ROM. Once written the CD-R cannot be altered.

CD-ROM: **C**ompact **D**isc - **R**ead **O**nly **M**emory, often abbreviated to CD

CGI: **C**ommon **G**ateway **I**nterface. A method of running server-side programs on the World Wide Web

Chat: A synchronous, text-based, communications mode in common use on the World Wide Web.

client-server: a strategy for computer communication through which the client acts like a customer ordering goods (in this case data) from a supplier, the server. Both client and server are computer programs, usually running on different computers.

cognitive apprenticeship: an educational strategy based on a learner gathering his/her understanding (cognition) of a topic from an expert in that topic.

COMET: **C**ooperative Program for **O**perational **M**eteorology, **E**ducation and **T**raining

communications and information technology: a term being used increasingly to replace "educational technology" in recognition that communications technology (Internet) is as important as computers themselves.

content-free: describes a computer program in which the user (trainer) provides the data (content) which appears on the screen when the program runs.

continuation training: training given to someone who has been working for some time, either to equip them for another job or to train them for new work-practices or knowledge.

conventional training: training where the trainees and trainers meet face-to-face in lectures and practical sessions.

DVD: Digital Video Disc - similar, and generally compatible with, CD-ROM but capable of storing about 7 times more data.

distance learning: training where the trainee is at a different location from the trainer.

educational technology: any technology, but usually computer-related, which can influence learning.

email: electronic mail. The most common computer-based communication medium.

EuroMET: **Euro**pean **M**eteorology **E**ducation and **T**raining.

FAQ: **F**requently **A**sked **Q**uestions and their answers.

FDDI: **F**ibre **D**istributed **D**ata **I**nterface. A computer network communications protocol.

firewall: a barrier (hardware and/or software) between two computer networks which can be controlled to allow only selected communications through. It is usually used to restrict inward access to a secure network while permitting outward access.

ftp: **f**ile **t**ransfer **p**rotocol. A platform-independent protocol for transferring files between computers.

formative evaluation: evaluation carried out during the formative stages (i.e. during course development)

foundation training: training carried out at the start of a trainee's career

HTML: **H**yper**T**ext **M**arkup **L**anguage. The language used to construct pages on the World Wide Web.

http: **h**yper**t**ext **t**ransmission **p**rotocol. The protocol used between client-server computers on the World Wide Web.

hyper-documents: documents which contain links from a word, phrase or picture in one document directly to a related document.

hyperspace: the conceptual space through which the links between hyper-documents travel.

ICT: Information and Communication technology - see communication and information technology.

Internet: the name given to the world-wide network which connects national computer networks together into an apparently unified network. Individual computers on any one network are then connectable to individual computers on any other network.

Intranet: the name given to a network which operates under the same protocols as the Internet but is internal to a single institution or organization. Intranets are usually much faster than Internet.

ISP: Internet Service Provider - usually a communications or telecom company which can provide access to Internet through a telephone line.

mirror sites: a computer (usually a Web server) which is automatically kept in the same state as another, remote computer in order to provide more than one point of access to the same information.

modem: modulator-**dem**odulator - a device which allows a computer to send and receive signals through a telephone line.

ISDN: **I**ntegrated **S**ervices **D**igital **N**etwork

ISO: **I**nternational **S**tandards **Organization**

Kbytes: a measure of computer storage equivalent to 1024 bytes (1 byte is capable of storing a single character).

MAN: **M**etropolitan **A**rea **N**etwork. A computer network connecting several different institutions in the same locality.

Mbytes: a measure of computer storage equivalent to 1024 Kbytes.

mentor: a person allocated to assist and support a trainee. A mentor is usually not a teacher but someone with more experience than the trainee.

MPEG: **M**otion **P**icture **E**xpert **G**roup. A digital video ISO standard.

multicast: a transmission method using a large-scale computer network to broadcast an audio or video signal while avoiding duplication on trunk network segments.

multimedia: the use of more than one medium (text, graphics, audio, video, animation, etc) in a computer program.

newsgroups: a type of bulletin board on thousands of different topics, with world-wide distribution.

nntp: net news transmission protocol. The protocol used for transmission of newsgroups.

OCR: **O**ptical **C**haracter **R**ecognition. The automatic detection of text from a scanned image of a page of text.

open learning: learning which is primarily under the control of the learner, who can study at a time and place to suit individual needs.

PC: **P**ersonal **C**omputer. Used here to refer to computers that support the Microsoft Windows operating system.

pedagogy: the science of education, training and learning.

pixels: picture elements, the dots of which digital images are composed

platform-independent: capable of functioning on any computer, not tied to one particular operating system or manufacturer.

plugins: software which allows specific programs to run within Web browsers.

presentation packages: programs for creating and displaying computer-based presentations (lectures or slide-shows).

QuickTime: A digital video format. Developed by Apple Computers.

resource sharing: the ability for a single resource to be used by more than one trainer or in more than one course.

re-use: similar to resource sharing but implying that the resource is used in a way which was not its original purpose.

scanner: a device for converting a paper page into a computer-based representation of the page.

SCHOTI: **S**tanding **C**onference of **H**eads **o**f **T**raining **I**nstitutions of National Meteorological Services.

search engines: programs designed to find information on the World Wide Web based on a few key words.

smtp: **s**imple **m**ail **t**ransmission **p**rotocol. A protocol used for sending email between computers.

streaming: used to describe different media (e.g. audio, video) elements when delivered on the World Wide Web in such a way that they starts to play before they are completely delivered and continue to play as delivery continues.

summative evaluation: evaluation carried out after a course has taken place to measure the total effect of the training

synchronous: a form of computer communication in which those involved have to be present at the same time (e.g video conference).

TCP/IP: Transmission Control Protocol/Internet Protocol. The computer communications protocol on which the Internet is based.

Unix: A computer operating system

URL: **U**niversal **R**esource **L**ocator. The addressing method of all World Wide Web documents.

Video-conferencing: a form of communications enabling all participants to see as well as hear the speaker. Can be based on computer or telecommunications networks. Can involve more than two locations.

Web: an abbreviation of the World Wide Web.

World Wide Web: the name of the information network based on the Internet and http. Access is usually through a browser. Herein World Wide Web is abbreviated to the Web but other common abbreviations are WWW or W3.

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4.1 Classroom and group working scenarios

The most traditional style of training is linked to a training “school”. An individual trainer has responsibility for designing and delivering much of a course but for a substantial course the work may be shared among several trainers who then must coordinate their efforts. Imagine that you are asked to prepare and deliver a course.

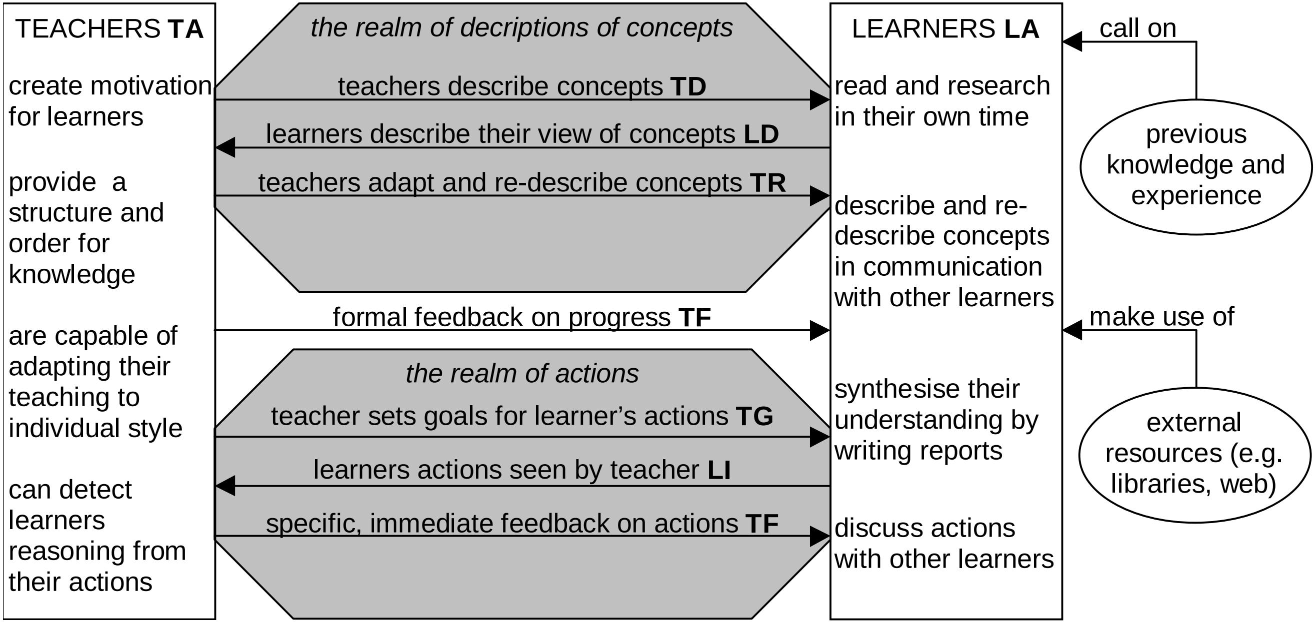
4.1.1 Preparation

Before any course preparation can begin it is essential that the trainer is clear about the training needs. These needs may be quite general, for example, to provide a basic knowledge of the meteorology which all forecasters require, or they might be quite specific, such as, to understand the changes in a new satellite system and be able to apply the enhanced observations in a forecasting role. These general needs are usually divided into more specific objectives, which detail precisely what the trainee should know or understand, after the training. Although the objectives or goals are quoted in some detail they may not always be easy to measure, particularly when the objective relates to understanding a topic. For this reason it is usually better to be able to describe the objectives in terms of specific competencies. That is, once a training objective has been met the trainee should be competent in carrying out specific work. By using competency as the objective of training, a high degree of professional capability can be ensured. In schools and universities it is common to teach a subject and then assess it by examination. Those who achieve some pre-defined pass mark are deemed to have adequately understood the course. Some people will pass with much better marks than others and will therefore be expected to have greater understanding or skill. The basis of training for competency is that everyone who passes is deemed to be competent. This means that a competent workforce is assured but it should be recognised that competency training cannot be carried out on the same basis as university courses. People learn at different rates and have problems in different parts of courses. In order to become competent in all aspects it is essential that trainees can spend more time on those topics with which they have difficulty and that they receive additional support at that stage of their training. Some people will reach competency in a shorter time than others, so flexibility of the total workload is also needed.

As the trainer concentrates on how to ensure that everyone can become competent, different styles of teaching will be considered. These include:

Activity	**Learning contribution**	**Timetabled unstructured**
Lectures	TD	■■■■■■
Group discussion	TD, LD, TA, TR	■■■■■■
Practical work (as individuals or groups)	TG, LI, LA	■■■■■■■■■■
Report writing	LD	■■■■■■■■■■
Reading	TD	■■■■■■
Working with CAL programs	LI	■■■■■■■■■■■■■■■■■■■
Simulations	TG, LI, LA	■■■■■■■■■■
Research (in a library, or through electronic means)	LI, LA,TD	■■■■■■
Providing feedback on trainee's work	TF,	■■■■■■■■
Informal discussion with other trainees	LD, LA	■■■■■■■■■■■■■■■■■■

The terms in the column headed "learning contribution" indicate types of learning activity. This analysis is based on the work of Laurillard (1993) who suggests that learning requires activities which involve teachers and learners. These activities need to include both descriptions of concepts and activities or interactions which relate actions to theory. In addition, it is necessary for learners to have time to reflect on their understanding and relate it to their prior knowledge and experience. Similarly, teachers need time to reflect on the work of their trainees, which often exhibits failings in their understanding, and teachers need to adapt their teaching to correct these misconceptions. This is shown conceptually below.


TEACHERS **TA**
create motivation for learners
provide a structure and order for knowledge
are capable of adapting their teaching to individual style
can detect learners reasoning from their actions
the realm of decriptions of concepts
teachers describe concepts **TD**
learners describe their view of concepts **LD**
teachers adapt and re-describe concepts **TR**
formal feedback on progress **TF**
the realm of actions
teacher sets goals for learner's actions **TG**
learners actions seen by teacher **LI**
specific, immediate feedback on actions **TF**
LEARNERS **LA**
read and research in their own time
describe and re-describe concepts in communication with other learners
synthesise their understanding by writing reports
discuss actions with other learners
call on
previous knowledge and experience
make use of
external resources (e.g. libraries, web)

The teacher must decide how the different learning activities can best be matched to the objectives or competencies.

Once the teacher has decided on activities it is usually necessary to identify the resources required (or available) to support these activities. Some such resources are:

Activity	**Types of resources**
Lectures	overhead transparencies, 35 mm slides, video, computer-based presentations
group discussion	charts, satellite images
Practical work (as individuals or groups)	instruments, charts, graphs, satellite images
self-study	textbooks, lecture notes, video, computer programs
Working with CAL programs	computer programs
Simulations	case studies, computer programs

Each resource to be used must either be produced by the teacher, be obtained from colleagues who have already produced it, or be obtained from outside your own organization. Sources within your own organization should be well known to you. If they are not, then you should take steps to make sure everyone knows what resources are available. Collections of resources exist in many meteorology training institutions and on CD-ROM so you should ensure that you are aware of what is available. The Internet is also a useful source of material.

4.1.2 Training

Once preparation is completed and a course is about to start, the trainer concentrates on making the most of each activity. Let's consider the different training activities in relation to a specific type of training – an introduction to numerical weather prediction.

4.1.2.1 Lectures

In most courses lectures play an important role. However, most lecturers also produce printed lecture notes or expect trainees to read scientific papers or textbooks so that lectures should not be considered only as a means of conveying information to the learners – they can absorb that information more readily by self-study of appropriate texts. The lecture has several important roles that are not possible in printed texts.

A vitally important aspect of lectures is to provide motivation for learning. This can best be done by an enthusiastic teacher using several anecdotes to illustrate the importance and relevance of the subject. If these anecdotes are clearly based on personal experience or on recent events they are particularly valuable.

Another use for lectures is to offer alternative or more detailed explanations of concepts. An experienced teacher will be aware of those parts of a subject which cause most difficulty and will be able to spend time in lectures explaining them in detail. It is often useful to confront the difficulties by describing the misconceptions and explaining why they are incorrect. However, care must be taken at this stage not to simply reinforce the misconception.

In many meteorological subjects, particularly NWP, mathematics offers a convenient way of expressing ideas concisely. Lectures offer a chance to discuss equations in some detail and offer a physical explanation. It is very important that equations are written clearly and using consistent symbols.

A lecture can also be an opportunity to provide a brief overview of another part of the course. If a computer simulation is to be used by each trainee in a practical session then a short introduction using a computer-based presentation in a lecture can reduce the time trainees take to become familiar with the software in the practical session.

4.1.2.2 Group discussions

Many activities which are sometimes presented in lectures, such as analysis of NWP products or the relationship between NWP products and satellite imagery, can be more effectively presented in a group discussion. Where the topic is a matter of interpretation and some degree of skill must be developed it is essential that there should be dialogue between the teacher and learner. Although this is possible, in principle, in a lecture it is more likely to happen if the session is identified as one in which discussion is expected. During such discussions the teacher should not be tempted to speak too much but should allow the learners to present their views. Occasionally a trainee will bring some useful prior experience to the discussion and other trainees will respond well to this. Even if the discussion develops in a way which is leading to misunderstanding it is often useful for the teacher to invite other trainees to offer alternative interpretations rather than to step in and offer a 'correct' interpretation.

One of the opportunities that a teacher should take in group discussions is to encourage trainees to express their own understanding of concepts which have already been taught. The teacher can then assess the trainee's level of understanding and can adapt a new explanation if misconceptions are apparent.

4.1.2.3 Practical work

Since meteorology is a practical subject it is vital that trainees learn to use the theoretical material and turn it into practice. Practical work should involve the trainees in trying to solve particular problems, for example, identifying regions of vorticity advection on forecast charts from an NWP model. If the practical work is more experimental, such as running a model with different initial conditions and interpreting the results, then a report should be written. The exercise should be designed so that its immediate product, a report or chart for example, is capable of revealing to the teacher the level of skill and understanding that the trainee has achieved. If there is no clear link between the practical activity, the product of the activity and the feedback which the teacher can give, then motivation for practical exercises can disappear. If the exercise is considered irrelevant it is worse than having no exercise at all. It is therefore important for the teacher to both ensure that exercises are relevant, and also that the trainees are briefed about the context of the exercise.

4.1.2.4 Simulations

In the context of an NWP course, two different types of simulation are common. One is a computer simulation in which the trainee can work with a simplified computer model, such as the 1-dimensional model available from the CALMet web site. The other is a simulation of a real working situation in which NWP products are used.

The purpose of the computer simulation is to allow the trainee to experiment. Such experiments are only effective if they give rapid feedback to the learner. Computer-based simulations work well whenever a trainee can have control over a few variables and some graphical output provides feedback. It is important in using these types of simulation that the trainee is given time to try many different options. It is common for the teacher to allocate insufficient time for this work because the teacher is familiar with the software and knows how to quickly achieve the 'correct' result.

Workplace simulations are a vitally important stage in training. These should be as realistic as possible, with trainees receiving the same support as they would in the workplace and having the same hazards as they would in the workplace, such as missing or delayed data. The products of the workplace simulation should be analysed in detail and group discussions are a good forum.

4.1.2.5 Self-study

Trainees on this hypothetical NWP course will have received lecture notes and will have access to textbooks. They will need time to prepare reports resulting from practical work. They may also find that they have insufficient time to complete computer simulations and will require access to computers and software in their own time. Self-study time is a period for learners to reflect and assimilate knowledge. It is at this stage that connections between knowledge, experience and prior education are formed and the actions of re-reading notes and writing reports aids this process.

4.1.2.6 Discussions among learners

It is a common belief that attempting to teach a subject is a good test of your own knowledge of that subject. The reason for this is that teaching a subject requires you to illustrate the structure of the subject to the learners. In the same way, formal or informal discussion between learners themselves requires them to reveal to each other how they make connections between different concepts and experiences. Sometimes false connections can be made. If learners can rationalise their experiences and observations in terms of these false connections to concepts then serious misconceptions can develop. One strategy to avoid this is to deliberately introduce challenges to common misconceptions. A simple example from NWP is to ask why we cannot forecast the weather 10 years ahead yet climate models are frequently used to predict climate change over centuries. Resolving these misconceptions is often a social activity which occurs between learners when the teacher is not present. As one student explains his or her understanding, others will recognise that this doesn't fit with either their own conceptual understanding or perhaps their own practical experience. Through discussions they can examine the misconception and either establish a more sound understanding or, alternatively, identify exactly what it is they don't understand so that they can ask the teacher. The role of informal discussions among learners is important and it should be recognised that this is often missing in some forms of distance training.

4.1.3 Evaluation

Evaluation is dealt with in detail in other chapters. In this section it is worth noting those styles of evaluation which are most appropriate for training based in a "school" environment. Questionnaires are useful because the same questions can be asked year after year and long-term trends can be established. However, questionnaires rarely examine learner's attitudes in great depth. The presence of learners in a "school" allows more detailed evaluation through interviews or focus groups. In interviews, a teacher is usually present and any problems which are identified can be explored in greater depth. Focus groups allow learners to discuss their views together and present a detailed evaluation in a more anonymous way.

For comparison with the following sections, and with your own teaching approach, a checklist is provided below which can be completed to illustrate how each of the different learning activities described earlier is achieved.

Checklist

Learning activity		**Methods of achieving learning**
Teachers describe concepts	✔	*Lectures, reading assignments*
Learners describe their view of concepts	✔	*Tutorial discussions and report writing*
Teachers adapt and re-describe concepts	✔	*Tutorial discussions, additional or modified lectures, additional or modified reading assignments*

Teachers give formal feedback on progress	✔	*Marking and commenting on written work*
Teachers set goals for learner's actions	✔	*Handouts, introduction to practical work*
Learners' actions are seen by teacher	✔	*Watching practical work*
Teachers give specific immediate feedback on actions	✔	*Interruption of practical work, demonstration of correct methods*
Learner's reflection and synthesis of understanding	✔	*Reading, report writing, discussion with peers, use of CAL and simulation programs*

4.2 Open learning scenarios

The most significant difference between open learning and more traditional learning is the shift in responsibility from the teacher to the learner. Traditional, lecture-based learning is often described as teacher-centered, meaning that the teacher decides the order in which to present topics, the time to spend on each topic and the pace of delivery as well as the time and place at which lessons will be given. During open learning these decisions are all made by the learner. Since the learner decides when to learn and for how long, motivation is of prime importance. Drop-out rates are generally higher in open learning than in classroom situations. In order to minimise these drop-outs it is essential to instruct the learner on their responsibilities as the manager of their own open learning.

In this section we will imagine managing an open learning course on the topic of interpretation of satellite images. Although open learning makes it possible for the learners to be distributed at various locations we will assume in this section that all the trainees and the teacher are located at a training school. In the next section we will consider distance learning.

4.2.1 Preparation

Careful preparation is much more important in open learning since the trainer does not immediately observe problems encountered by the learner. Furthermore, if the learner is to have some freedom in the order of studying different topics, the whole course must be fully prepared before any part of it is started. In this example we are going to take the extreme case where there are no scheduled classes at any time on the course. In many courses this is unrealistic and a mix of scheduled classes and open learning occurs. By adopting this extreme view we should uncover all of the potential problems.

One of the key decisions that the trainer must take is whether the course duration is to be limited or unlimited. Should the course run with a group of learners who all start and finish at the same time, but with enough flexibility in the structure to allow them to spend different amounts of time on different topics? Or should learners be able to start the course at any time and work through it at their own pace and finish it when the work is completed? While the unlimited approach is in keeping with the philosophy of open learning, it also leads to the highest drop-out rates. A course in which there are regular milestones and deadlines is much more effective at motivating learners and ensuring high completion rates.

When gathering course material the trainer must always recall that the trainee will be using the material, textbook, computer simulation or practical exercise, on their own. There can be numerous reasons why a learner is delayed in their study because they do not understand something which the trainer would be able to explain quickly if they were present. The most obvious problem is jargon. All trainees should have access to a good glossary which will provide an explanation of any technical terms – these may not always be meteorological terminology but could also be computer or communications jargon. Of course, this raises the question that some learners in a classroom may have similar problems with jargon and, for reasons of shyness or fear of showing ignorance, may suffer in silence. Sometimes the problems of the open learner are more subtle, for example they may not understand an explanation of the difference between visible and infra-red radiation. In a classroom the experienced trainer will usually detect a look on the learner's face and offer an alternative explanation, but in an open learning situation it is the trainer's responsibility to ensure that there are several different sources of information available.

The resources that must be gathered will normally rely quite heavily on printed material. Books and printed notes are superbly convenient: they can be read anywhere; personal notes can be made in the margin; they have useful contents and index pages making it easy to find relevant sections. Nevertheless, books do not provide opportunities to test theories, build skills, or practice procedures. Packs of satellite images will play a useful role in this course but computer-based practical work is particularly important because it can provide some of the feedback that is missing in the trainer's absence. Since satellite meteorology is an essential subject in every meteorological service there are many resources available and the trainer should be able to gather them from other organisations rather than have to produce them.

4.2.2 Training

The active learning stages in an open learning programme will be as varied as the number of trainees taking part in the programme. Everyone can tackle the work in a way which suits their own learning style and their own prior knowledge and experience. To illustrate this we will consider a day in the life of two open learning trainees, Bernard and Sophia.

4.2.2.1 Bernard

Bernard has no previous experience of looking at weather systems on satellite images and is keen to improve his interpretation skills. He starts each day by using a web-based exercise called "Today's satellite image". This shows the image with each of the major features, usually between 10 and 15 every day, indicated by a spot on the screen. He selects a region he considers to be an obvious warm front, selects the warm front label to show his choice and checks his analysis against the expert. Correct! This daily practice is obviously paying off! He identifies another region as a cold front but this time he is wrong. The expert has identified this region as an occlusion and offers a link on the computer screen to more information on how to identify occlusions. Bernard clicks to follow the link, reads about occlusions, sees several more examples, and takes a short quiz on the differences between occlusions and cold fronts and then returns to "Today's satellite image". He is making fewer misinterpretations every day and is starting to recognise the different signatures of synoptic features on visible, infra-red and water vapour images. After spending over an hour on the computer, Bernard feels like reading for a while. He starts on the chapter of the recommended textbook describing how temperature profiles can be deduced from satellite instruments. This is difficult stuff! He gets stuck initially on the meaning of the term “retrieval” but once he has used the glossary it helps him to make some progress. There is a lot of mathematics in this chapter but that isn’t a problem because Bernard has a good background in maths and he doesn’t need to spend much time on those sections. It is the concept of weighting functions and their relationship to the wavelength of the radiation with which he is having trouble. He decides to use another book that covers the same material. It helps a little but he is still not comfortable with his understanding. He knows that he has to write a report on this next week and he hasn’t really been able to relate the different parts of what he understands. He makes some notes that he can re-read next week.

At lunch he meets some of the other trainees on the same course and starts telling them about the problems he has been having. Several of them try to give their explanations but they are contradictory and everyone realises that they are all confused. Just then, the trainer joins them at the table and they tell him about their problems. He is used to this and explains that it is a “frequently asked question”. Almost everyone has problems with this topic every year. He suggests that they look at the computer-based discussion forum and if that doesn’t enlighten them they should contact him.

Bernard decides to go to the computer room and look at the discussion forum immediately. Some trainees have their own computers connected to the network from their own rooms but he can’t afford one. That isn’t a major problem because he can use the computer room at any time of the day or night, weekday or weekends. The discussion forum is organised into topics and he soon identifies the part he needs. He finds that a trainee from two years earlier has submitted a list of questions to the forum that almost exactly match his questions. He then follows a series of replies to that trainee’s questions. Some of these replies come from other trainees but many come from trainers. In fact the ensuing discussion reveals that the trainers have slightly different interpretations and their on-line discussion on how to resolve these different interpretations enables Bernard to clear up his problems.

For the rest of the afternoon Bernard works on an analysis exercise. He has been provided with satellite images and printouts of NWP data and has to identify regions where he would expect heavy precipitation. It takes a while but he manages to finish it and hand it in to the trainer before tomorrow’s deadline. At the evening meal he mentions that he has finished the exercise to a colleague who asks if he did it on paper or on the computer. Bernard explains that he likes to spread out all the charts and images and be able to look over them all at the same time. His fellow trainee says that she finds that a difficult way to work. She did the exercise on the computer where she was able to display the satellite images and overlay different NWP field directly on top of them.

Although Bernard feels he has worked hard he is aware that there will be a test the next day on features of the electromagnetic spectrum. He decides to return to the computer room and take one or two of the self-assessment tests on this topic to make sure he is ready. He likes the self –assessment tests because he gets feedback on any wrong answers which explain why that is the wrong answer. He does quite well, but recognises a couple of areas in which he needs more revision so he goes back to his room and reads the relevant chapter in his favourite textbook

4.2.2.2 Sophia

Sophia has been a meteorologist for several years but has only recently moved to a job where she needs to know about satellite images. She has seen many images before and is comfortable with identifying synoptic scale features. She has much more difficulty with mathematical topics and in particular she is confused about satellite orbits. In the next few days Sophia must write a report comparing the relative advantages and disadvantages of polar-orbiting satellites and geostationary satellites. Sophia has had trouble understanding orbits but hasn't been able to clearly identify exactly what it is that she needs to be clearer about. She recalls that at the beginning of the course it was stressed that open learning puts a lot of responsibility on the trainee to manage their learning. In the last few weeks she has really welcomed this because, while Bernard and his friends have spent a long time on the image interpretation exercise, she found it quite simple. So she has been able to apply more time to some revision of basic mathematics, which is now helping with this orbits problem. Now she realises that another aspect of taking responsibility for your own learning is that you also have to be able to identify what is causing difficulty. She decides to call on her fellow trainee, Jose, who seems to understand satellite orbits and discuss it with him. They decide the best thing is to start at the beginning and establish where she starts to have problems, but where is the beginning? They both recognise that their trainer has used his expertise to provide a course plan which suggest an approach they might take. They start with the introductory material in the recommended textbook and soon realise that the jargon is a major problem. Sophia has difficulty conceptualising some terms, which are used frequently, such as inclination angle, sun-synchronous and geo-synchronous. Referring to the glossary doesn't help much and as Jose tries to explain Sophia realises that he is using his hands a lot to try to describe three-dimensional motions. That's it! Sophia needs to visualise orbits in three dimensions. She emails the trainer to ask if there is some way she can do that. He suggests she goes to the computer room and use the "orbits virtual laboratory". This is a collection of simulations in which a satellite orbits the Earth and the Earth orbits the Sun. The key thing that helps Sophia is that she can alter her viewpoint to see what happens as she changes parameters like the satellite altitude and inclination angle. After an hour experimenting with the computer simulation, Sophia decides to take the on-line test to see if she now understands. The test asks her to choose parameters for sun-synchronous and geo-synchronous orbits. She now understands geo-synchronous and gets it right first time but she has problems with sun-synchronous. She uses the feedback option to get advice. The software can tell her which parameters she has set correctly and when she adjust some, such as the inclination angle, it can tell her if she is making it too large or too small.

In the afternoon, Sophia decides to use the discussion forum to ask some questions on infra-red radiation. She has already looked for answers and found that no-one seems to have asked these specific questions before. She knows that it will take a while to get answers so she works on reading the textbooks and writing reports for most of the afternoon. Just before finishing for the day she checks the discussion forum and finds that two of her questions have already been answered. Her course tutor answers one but the other is answered by an experienced forecaster who has answered the questions and given several examples of how it is used in his everyday work. Not only has Sophia got the answers to the questions but also she sees how the discussion forum has grown and these questions and answers are now available for other trainees to read.

4.2.3 Evaluation

In one sense open learning can be evaluated in just the same way as traditional learning. The same techniques of questionnaires and interviews are just as valid for open learning.

However, an added dimension to open learning is that it is necessary for the evaluator to identify the learner's working methods and ensure that resources are provided to allow each learner to work using their own chosen strategy. Trainees who choose to work one way, rather than another, should not be disadvantaged.

Some of the factors which must be considered are: access to resources (textbooks, computers, study areas); response times when questions are submitted electronically (by email or on discussion forums); monitoring progress. The last point is particularly important in open learning where the trainer has less contact since a trainee can fall well behind without being identified unless the trainer carefully tracks the progress of each trainee. This can be done in several ways. Encouraging continuous interaction (e.g. by email), and by requesting small amounts of work to be submitted not only requires the trainee to keep working but also gives the trainer the opportunity to comment on the progress either formally or informally. Computer-based systems (self-assessments and simulations) can also monitor the progress a trainee is making and report it to the trainer. These automated methods can introduce an element of fear on the part of the trainee and they must be told what is being monitored and what use will be made of the information obtained.

Checklist

Learning activity		**Methods of achieving learning**
Teachers describe concepts	✔	*Textbooks, prepared notes, study plans*
Learners describe their views of concepts	✔	*Written reports and taking part in discussion forums*
Teachers adapt and re-describe concepts		
Teachers give formal feedback on progress	✔	*Comments on written reports*
Teachers set goals for learner's actions	✔	*Handouts for computer-based activities and practical work*
Learners actions are seen by teacher	✔	*Only some actions are detected by computer programs*
Teachers give specific immediate feedback on actions	✔	*Self-assessment tests and instant feedback in computer programs, but all of it is pre-determined*
Learner's reflection and synthesis of understanding	✔	*Reading, report writing, discussion with peers, use of CAL and simulation programs and discussion forums*

The examples given in this section are just one way that open learning could be implemented. It is an extreme example in which the trainer has a very important role as facilitator and provider of resources but has little immediate contact with the trainees. In some circumstances this might be useful, for example when a trainer is only available on a part-time basis. In general, however, open learning in a school environment would involve a great deal more interaction with the trainer and this would give opportunities for the learner's responses to influence the guidance the trainer would give. Open learning can be weak if there is no role for the teacher to adapt the teaching to the developing needs of the learners.

4.3 Distance learning scenarios

Distance learning occurs when the trainer and trainees are physically separated. It may be that the trainees are in small groups at forecast stations around the country or they may be individuals, for example studying at home. Although the trainer is not in the same place as the trainees they may still have more experienced staff in their vicinity to whom they can turn for help. In this example we will consider a situation in which a new national rainfall radar network has just been established throughout one country and there is a need for all meteorologists in the country to know what it is capable of and how to interpret its products. There is also a need for a smaller subset of staff to become more aware of the technical capabilities of radar systems. These staff will later be regarded as the local radar experts. This is an ideal situation for distance learning. It would be an almost impossible situation for traditional learning as no organisation can afford to train almost all of its staff in a very short time on courses which would remove them from their usual duties.

4.3.1 Preparation

The introduction of new technological methods is common in meteorology – rainfall radar; satellite imagery; satellite sounding; model output statistics from NWP; Doppler radar; forecaster workstations with advanced visualisation capabilities. In each case it is important that hundreds or thousands of staff should be trained in how to use these new methods and the training must be synchronised with the introduction of the technology. These technological developments often take years to implement and the preparation of the training should be an integral part of the whole plan. In our example of a new radar network we would need to define the user requirements in terms of the information and skills which staff will need to do their job. This might result in a list containing topics such as the following for the training of all staff:

- principles of rainfall radar
- familiarity with radar output products
- relationship of radar products to satellite images and NWP products
- identification of meso-scale features
- forecasting examples

In addition, a training programme for radar specialists would include the same topics to a much greater depth and could also include additional topics such as maintenance of radar systems or meso-scale conceptual models and their visualisation on radar. If the specialists are trained first they can act as local mentors when the other staff are trained. In the following discussion we will concentrate on the delivery of training to all staff after the initial training of the radar specialists. The specialists could be trained using the same distance learning approach or an open learning or traditional approach.

In this example the trainer (or group of trainers) will be responsible for developing training material for a large number of people but will have little or no personal contact with these people. The trainers must consider the content and the mode of delivery of the training. One solution might be the following:

Content	**Mode of delivery**
Introduction and motivation	Video-conference, video-tape or video-CD
Principles of rainfall radar	CD-ROM and mentor tutorials
Familiarity with radar output products	Web-based course with on-line 'live' discussions
Relationship of radar products to satellite images and NWP products	Video-conferenced tutorials using shared applications on a computer network
Identification of meso-scale features	Collaborative project work between remote groups supported by discussion forums
Forecasting examples	On-the-job practicals run by the local mentor

It would not usually be a good idea to use a different technology for each part of a course. This approach is used here only to illustrate several different styles. The selection of mode of delivery for each part of the content is not entirely arbitrary but other options are certainly possible. The different modes of delivery are discussed in detail in the next section. It is assumed that the local mentor at each location is the person who has already taken the radar specialist training course.

An important part of the preparation for this type of training course is to ensure that the appropriate technology is available at all locations and that people are familiar with its use.

4.3.2 Training

The order in which these sub-sections are presented does not imply that in practice they follow one after the other. It may be that they all occur in parallel or that one location takes them in a different order or spends more time on one part than another. Such flexibility is limited by the number and timing of activities that involve all trainees.

4.3.2.1 Introduction and motivation: Video-conference, video-tape or video-CD

At the beginning of a major technological advance and its associated training programme it is important to ensure that everyone recognises the importance of the changes and the benefits they will bring. A high-profile launch might involve the head of the weather service speaking to all those taking the course. Since a personal meeting with everyone is unrealistic there are three options:

- Video-conference: It is possible to use ISDN telephone lines to send sound and pictures to a widely distributed audience. This would not only allow the speaker to be visible but broadcast clips of video-tape could also be included. The main advantage of a video-conference however is that it is interactive and the audience can ask questions.

- Video-tape: The simplest technological solution is video-tape because it is easy for almost anyone to play. It also allows a high-quality product to be produced in an editing studio but has the disadvantage of allowing no feedback.

- Video-CD: If the rest of the training is to use multimedia computers then another option would be to put the video in digital form on a CD-ROM so that it can be viewed on the multimedia computers at the remote sites. This has the advantage that it provides random access, so that the parts of the sequence can be skipped or watched again easily. The digital video sequences can also be re-used in other parts of the training course and it highlights the technology being used to deliver the course. Like video-tape, it has the disadvantage that it is not immediately interactive but links could be provided which would allow questions to be asked and answered by email. In terms of large-scale production costs, it is now cheaper to produce a CD-ROM than a video-tape.

4.3.2.2 Principles of rainfall radar: CD-ROM and mentor tutorials

Delivering a course on CD-ROM, along with a textbook or printed material, is very similar to the open learning discussed earlier. It allows trainees to be in control of the pace and structure of their studying. It allows them to interact with material, which can be highly graphical, encouraging learning through visual and active modes, rather than only through reading. It can provide immediate feedback on anticipated problems. It can contain open-ended simulations which allow the trainee to experiment in a “virtual world”. The main weakness of open learning, identified earlier, is that trainees working alone may not be sufficiently closely monitored by a trainer and the trainer would not be able to adapt the programme to suit the trainee. In this case that would be overcome by the local mentor who would have regular meetings with the local group to discuss progress and ensure a satisfactory degree of understanding, perhaps through some forms of intermediate assessment. CD-ROM delivery is best suited to material which is not rapidly changing. Basic principles of radar and a few examples are ideally suited to this medium but it would not be used for distributing regularly updated data. Nevertheless, it is also possible to produce “hybrid CD-ROMs” which make the most of the CD-ROM medium and the Web. If a particular part of a course included a video sequence showing severe flooding and an example of the radar situation at the time of the flooding then that might best be provided on CD-ROM. But if the lesson is designed to continue by examining that day’s radar situation to examine the risk of flooding then a link from the CD-ROM to a Web site would provide the most up-to-date information.

4.3.2.3 Familiarity with radar output products: Web-based course with on-line ‘live’ discussions

Although radar products could be presented on a CD-ROM it would have more impact if the products could refer either to recent weather events which the participants can easily recall, or the current situation. Both of these are possible if the Web is used for delivering the course. This is easily achieved because the Web is based on a server-client strategy. The central training organisation can provide a web server on which a range of different synoptic situations is provided. These can be changed easily if a new and interesting situation develops. At all times, every remote site will see the same material on the web server as soon as it is updated. The material itself is not a source of training – it is the informed discussion of the material which is important. Here again, the Web is important because it can offer a medium for holding discussions over long distances. In this case of up-to-the-minute weather situations it would be best to have up-to-the-minute discussions. This could be achieved by having a 'radar briefing' at a predetermined time each day. Staff at each remote site can look at the current radar images on screen and can open a window on their screen in which a typed dialogue can occur about the images. Everyone can type and everyone else will see what is being typed. One person might ask when rain might be expected to start in a particular city and three people might all contribute their answers. The ensuing discussion will raise various interpretations of the image. If this is repeated on a daily basis everyone involved rapidly develops their interpretation skills and also feels part of a community which is much wider than their local colleagues. Discussions may continue after the briefing session by email or in discussion forums. Since the discussion uses typed text rather than speech or video the bandwidth required is minimal and fully interactive chats are possible even on the slowest modems.

4.3.2.4 Relationship of radar products to satellite images and NWP products: Video-conferenced tutorials using shared applications on a computer network

This example couples two technologies which, in combination, can be used like a skilled instructor sitting next to someone learning a complex computer-based task. Imagine that a forecaster is already familiar with a software system he uses every day to analyse satellite images and NWP products. Part of the introduction of the new radar network is to introduce new facilities into this software system that permits radar products to be processed and combined with the NWP and satellite products. The purpose of this part of the course is to introduce all forecasters to these new facilities and show what they are capable of. At predetermined times an expert in one location holds video-conferenced tutorials. The participants at each of the remote sites can see and hear the expert, as if on live TV, but they can also participate in an audio discussion heard by everyone at all remote sites. The picture on TV automatically switches to the person who is speaking. The expert starts by explaining what features of the software will be discussed in this lesson. He then starts up the software system on his computer. By using 'shared application' software each trainee at the remote sites has a copy of the expert's screen on their own computer. As the expert selects menus, clicks on buttons and highlights areas on screen, the trainees see it all happening on their own computers. At the same time the expert still has audio and video contact and is describing all his actions. He is effectively giving a highly technical one-to-one tutorial to a large number of trainees simultaneously. Up to this point the tutorial is very one-sided. The expert tells the trainees what to do and they listen. The next stage is to hand control to the trainees. The expert invites one of the trainees to perform a specific task using the software. When that trainee starts to work she has control of the system and now every person at the remote sites, and the expert, sees what she is doing on screen and hears what she is saying. If she has problems she can ask for help and the expert can tell her what to do or can take back control and demonstrate what to do. Each person in the group can take turns to try their own skills under the careful eye of the expert. Once they are all confident they can use the software at their own local site in their own time. If they have further questions they can wait until the next video-conferenced tutorial or they can send email to the expert or use the discussion forum to see if their problem is a frequently asked question.

4.3.2.5 Identification of meso-scale features: Collaborative project work between remote groups supported by discussion forums

In this part of the course groups of trainees are asked to work together. The trainees are from different sites and will need to collaborate over a period of time to produce a report. The report should contain a detailed assessment of a case study in terms of the meso-scale circulations apparent in the radar data. Several case studies are provided. All of the data needed are provided on the Web so that each of the remote groups has easy access. In addition to the case study data, the web is also the source of several collaborative working tools which the trainees will use. There is a web site to which they can each upload text and images, a chat page on which they can have live discussions at pre-arranged times, and a discussion forum on which they can raise points and comment on points others have raised. They start by having a chat session in which they decide to split up the work allocating a part of the work to each participant and agreeing to have another chat in a few days time. When each person has produced a part of the report they upload it to the web site so that the others can see it. Some send comments about the parts that others have written to the discussion forum and an argument develops. It seems that the argument can only be resolved by performing a more detailed analysis on one of the radar images. One person volunteers to download the image, process it and upload the result. The discussion continues about how best to present the results. Another chat session is held to discuss revisions for the final report and it is decided that each participant will take a section that someone else wrote and revise it. One person was ill while this last chat occurred but, since transcripts of these chat sessions are kept automatically, he could immediately see what was decided. Once the participants got to know each other and their different skills they continued to communicate throughout the course and discuss their various assignments.

4.3.2.6 Forecasting examples: On-the-job practicals run by the local mentor

Not all of the work is computer-based. Some forecasting case studies have been prepared and distributed to sites so that the local mentor can run practical sessions. These are designed to be as close to realistic forecasting situations and each of the participants has a different role to play. Since there are several different cases everyone gets the opportunity to play all of the different roles. This work not only gives each trainee a chance to assess whether or not they have developed their skills as well as they would like but it gives the local mentor a chance to identify weaknesses in the group and arrange for additional work or revision as appropriate.

4.3.3 Evaluation

Evaluation of distance learning, like open learning, requires special techniques. It is important, whenever possible to be able to observe the learning experience and even to record it, possibly on video-tape. Where the trainees are working through a computer interface it is important to be able to identify if the interface gets in the way and interferes with the real objectives of the learner.

As before, we can check the list of learning activities to see how they are met in this example. Of course, each of the various parts of the course will not contribute to every learning activity. But the full distance learning course provides a rich mixture of different types of interactions: between learners at the local and remote site; with ‘live’ and case study data; with experts both locally and remotely.

Checklist

Learning activity		**Methods of achieving learning**
Teachers describe concepts	✔	*Video-conference, CD-ROM, web-based courses and local mentors*
Learners describe their view of concepts	✔	*Tutorials with local mentor, video-conference tutorials with remote expert, chats with other remote trainees and through discussion forums*
Teachers adapt and re-describe concepts	✔	*Video-conference tutorials, local mentor tutorials and on-the-job practicals*
Teachers give formal feedback on progress	✔	*Marks and comments on reports*
Teachers set goals for learner's actions	✔	*Video-conference tutorials, collaborative working guidelines and local on-the-job practicals, interactive exercises on the Web and CD-ROM*
Learner's actions are seen by teacher	✔	*Video-conference tutorials, local mentor tutorials and on-the-job practicals*
Teachers give specific immediate feedback on actions	✔	*Video-conference tutorials, local mentor tutorials and on-the-job practicals, as well as pre-defined responses through CD-ROM and web-based interactive exercises*
Learner's reflection and synthesis of understanding	✔	*Self-study time, preparation for collaborative project work*

4.4 Managing open and distance learning

It should be clear from the previous sections in this chapter that the differences between traditional, open, and distance learning are not as important as is the design of the course to ensure that a wide range of learning activities are included. Planning for open and distance learning does require a different strategy to traditional learning and it is worth concentrating now on a few specific management aspects which are important if open and/or distance learning is be successful.

4.4.1 Equipment

Although distance learning can be carried out with a correspondence course and open learning could simply replace lectures with more time for reading, the real benefits of these modes of learning come through the use of computers and computer networks. This reliance on equipment raises three major issues: reliability, fear and access.

4.4.1.1 Reliability

Every trainee who uses a computer as part of the learning resource provided on a course has the right to expect that all the necessary software will always be available. The same version of the software should exist in all available machines. Buttons and menus should do exactly the same on every machine. Services such as printers, email and Web access should be available on all machines. It is the responsibility of a course organiser who expects trainees to rely on these computers to ensure a management policy exists that states what level of service will be provided.

4.4.1.2 Fear

Some people do not like to work with computers. These people will find it much more difficult to learn in a computer-based environment. It is important to recognise these problems and provide special treatment for these people before they take a computer-based course. One option is to offer a version of the course without computers but, in the world of modern meteorology, it is a much more realistic approach to develop a strategy to help people overcome their fear.

4.4.1.3 Access

Computers have many uses other than for training. It is tempting to allow them to be used for different purposes in the same location. For example, a computer might be used as a forecaster's workstation while, at the same time, being used as the local training computer for on-the-job training. In many cases this leads to conflicts, which reduce the amount of time computers are available for training. The access to computers must be guaranteed for trainees who rely on them to complete a course and the calculation (number of hours x number of trainees) does not give the complete answer because hours must be at suitable times. In fact, it is useful to calculate

$$\frac{\text{number of hours of computer access per trainee} \times \text{number of trainees}}{\text{number of available computers}}$$

which will result in the number of hours computers need to be available solely for the use of these trainees.

In some cases it is convenient for computers to be available for self-study in the evenings or at weekends. At other times a period of availability during the normal working shift is required. The total access requirements and hours of access are part of the essential pre-course planning.

4.4.2 Time

Traditional courses have a fixed duration. There is an absolute recognition of the amount of time needed to do the work of the course. Open and distance learning courses also need similar amounts of time. It may be that the time spent in these learner-centred courses is more effectively used but it must still be recognised. Open learning can often be used as a form of just-in-time learning. That is, the course is taken at just the stage in the trainee's career when they need it. It may be that there is a pressure on the available time but it is vital that those managing the trainees ensure that they are allocated adequate time to complete the course. Similarly, distance learning courses are usually taken as a form of on-the-job training. This implies that the training is done in addition to the normal duties of the job. Time must be allocated to allow trainees to leave their normal duties to undertake the on-the-job training. It should be recognised that considerable savings are made through on-the-job training since the staff member is still available for work and no travel or subsistence costs are incurred. It should not be expected that further savings will be made in terms of the time available for training.

4.4.3 Tutors

One of the major differences between open and distance learning and traditional learning is the reduced amount of contact between trainer and trainee. This does not imply that there is a reduced need for trainers. In fact the trainer needs to be more skilled for open and distance learning because they need to be able to anticipate the trainee's learning difficulties in advance and be able to plan strategies to help them. The person responsible for planning an open or distance learning course puts in much more work before the start of the course than in traditional learning. During the running of the course the course planner may take more of a backseat role. In distance learning the tutors may be accessible electronically or may be distributed local tutors or mentors. The role of the local mentor is particularly important. In many cases this role will be filled by someone with much more experience of the job but not much experience as a teacher. Mentors should be given training in teaching as well as being expected to pass on their on-the-job skills.

4.4.4 Monitoring

Since student-centred learning can develop into students-not-learning it is vital to plan a strategy before running any open or distance training which allows the progress of each individual to be monitored. Failure to do so would be to cast some trainees adrift in a sea of learning without benefit of a compass or rudder. Regular contact between trainees and trainers is essential and the assignments should be capable of distinguishing if the work is being understood. Monitoring of access to computer packages is also possible although giving responsibility to the trainee also means they can choose which form of learning suits them best.

Another aspect of monitoring relates to the use of discussion forums. These are actively used and people will return to them frequently if they are seen as the source of rapid answers. Tutors should monitor when new questions are posted to discussion forums and ensure that responses are made quickly, usually within a few hours.

4.5 Questions for consideration

This chapter has given several examples of different scenarios in traditional, open and distance learning. None of them is perfect and in most cases a course can easily be composed of elements of all three modes of delivery. Here are some questions to consider the next time a course is being planned.

1. If you were examining two trainees, one of which had taken a traditional course and the other had taken a distance learning course, could you tell which was which? If you think you could, what would be different?

2. If you planned to deliver a course only by distributing CD-ROMs which vital learning activities would be missing?

3. If you evaluate a lecture course and 50% of trainees say the pace was to fast and 50% say it was too slow what do you deduce – that the pace was about right, or that 100% of trainees were dissatisfied?

4. How does a video conference differ from a traditional lecture? Try to answer the question from the trainer’s point of view and again from the trainee’s point of view.

5. Have you tried using a computer display during lectures? If not, try listing the reasons why not? How many of them are educational reasons and how many are logistical?

6. Have you ever used a discussion forum? Why not try it by setting up a forum either for a group of trainees to use on there own or for your colleagues to use

7. You probably answer many of the same questions from trainees every time you run a course. What do you do to ensure that the answers you gave last time are made available to the next group of trainees?

8. If you plan to change a course which is currently run as a 3-month residential course into an on-the-job distance learning course, how long should trainees take to complete the new version?

9. If 20 trainees needed to use one computer each for 24 hours per week in your training establishment do you have spare capacity to accommodate them? If not, could you extend the hours your computers are accessible at night or at weekends? Which is cheaper – improving accessibility or buying more computers?

ANNEX

This Annex contains references to training materials and resources for use by instructors in self-study and or research modes for their own development as well as for teaching purposes. It should also serve as a guide for instructors in locating additional materials, especially those available on or via the World Wide Web (WWW).

In this connexion, a number of Internet search tools are listed and described on the website at http://www.cc.columbia.edu/cu/lweb/search/internet.html.

HOW TO USE ON-LINE TRAINING RESOURCES

Information resource for those who teach adults in the online classroom. Includes tips and best practices in management, development and implementation of online courses. Site Trainer is a resource dedicated to providing resources to online faculty members, or faculty-in-training, who want to improve and enhance their skills in teaching with technology.
http://www.sitetrainer.com/faq.cfm

Training Trainers to Use the Internet
Dominique Leclet Université de Picardie
Jules Verne Gerard Weidenfeld Université de Picardie Jules Verne The use of Internet in a training context modifies implicitly the trainer's behaviour and role.
www.coe.uh.edu

Searching Strategies on the Web
Much of this course is based upon the 'Sink or Swim: Internet Search Tools and Techniques' workshop written by Ross Tyner.
http://www.lboro.ac.uk/info/training/finding/search23.htm

ON-LINE LIBRARIES

Library Services via WWW
LIBWEB lists pages from libraries around the world.
http://www.sunsite.berkeley.edu/Libweb

Queen's SunSITE - Resources for Training the Trainer
Resources for Training the Trainer. Learning Applications
A library of Internet-based instruction ...
http://www.sunsite.queensu.ca/localov/resource.html

UNESCO Libraries Portal
"The UNESCO Library Portal is intended to enhance access to information related to library resources available on the World Wide Web as well as to issues affecting librarianship. The site provides links to websites of libraries and information centres around the world and will serve as an interactive point for browsing and searching a range of categories including websites of national libraries, government information services, library associations and on-line resources. It will also provide news about conferences and training opportunities."
http://www.unesco.org/webworld/portal_bib

The WWW Library Directory
Currently indexing over 7350 libraries and library-related Web sites in 130 countries. And while you're at it, check out the related site: The Great Library Card Collection
http://www.webpan.com/msauers/libdir

Freeality Online Libraries and Reference Search a wide variety of online libraries and catalogues. Complete reference and research site. Find college libraries.
www.reverse-lookup.com

Mega-Websites
It is not our intent to list all of the fine training, development or HRD related sites. Instead, we point you to several wonderful mega-lists that will lead you to many more web sites.
http://209.130.96.48/web_sites.htm

WMO Virtual Training Library
http://www.wmo.ch/web/etr/vtl.html

BOOKS, PUBLICATIONS, PAPERS

The Educational Development Resource Center. Concept mapping resources. (This reference is relevant to Chapter 2).
http://www.hednet.polyu.edu.hk/CMWkshp_folder/CM.ResFolder.html

Gaines, B.R. and Shaw, M. (1995). Collaboration through concept maps. (This reference is relevant to Chapter 2).
http://www.ksi.cpsc.ucalgary.ca/articles/CSCL95CM/

Lanzing, I. (1997). Former HomePage of Dr. Ian Lanzing. (This reference is relevant to Chapter 2).http://www.to.utwente.nl/user/ism/lanzing/cm_home.htm

Plotrick, E. (1997). Concept mapping: A graphical system for understanding the relationships between concepts. (This reference is relevant to Chapter 2).
http://ericir.syr.edu/ithome/digests/mapping.html

Training Managers to Train
Learn how to prepare for, plan, present, and follow up on training programmes. Checklists, tips, and activities help sharpen basic training skills for any manager regardless of experience.
£10.95, 96 pages

Training Methods That Work
Trainers who want to sharpen their training skills will find this book a valuable tool. It describes specific innovative training methods and provides guidelines on how to select the best one.
£10.95, 96 pages

50 One-MinuteTips for Trainers
Examines the purpose and importance of training and development programmes, presenting clearly and succinctly the fifty most important tips to consider before any training session.
£10.95, 96 pages

Developing Instructional Design
This self-study primer describes the four steps in instructional design. After completing this practical self-study book, readers will be able to organise and present ideas in meaningful learning modules, function effectively as instructors and measure their own effectiveness.
£10.95, 80 pages

Delivering Effective Training Sessions
This book teaches the best techniques available in training today, explaining how to use icebreakers, audio and visual aids, group interaction, and personal style to deliver an effective presentation. Case studies and role-plays allow readers to practise techniques that will make them successful.
£10.95, 120 pages

Successful Lifelong Learning
Deals with the strategy of learning as an adult and the need to accept the principle that lifelong learning is not just a catchy phrase but something that will be part of most people's lives from here on. Outlines six key strategies for learning and uses the easy 50-Minute format to explain and develop the reader's ability to get the most from any effort at continuing education.
£10.95, 96 pages

> All the above-mentioned publications are available from:
> Crisp Publications, distributed by Flex Learning Media Ltd
> 9-15 Hitchin Street, Baldock, Hertfordshire SG7 6AL England
> http://www.flexlearningmedia.com/crspagesfolder/training.html

Learning Objectives.and Beyond
By Richard R. Wigley, Ph.D.
Closing the "Gap" between the classroom and the job shows how to develop learning objectives, which are performance based. The process teaches effective transition of job tasks to learning objectives. This book is MUST reading for every trainer who wants to produce results on-the-job.
CAN $8.50

Training vs. Education
By Dr. Jack Asgar and Dr. James Cook.
"In education the focus is on acquiring skills; in training the focus is on utilizing skills." This significant difference is discussed
One cassette, CAN $16.00

Tips on Training Techniques
PMI's senior consultants present a variety of practical ideas for improving your classroom skills.
One cassette, CAN $16.00

Managing Training Resources. A Strategic Plan
Dr. Jack Asgar and Dr. James Cook discuss an approach to make the most of your training resources and survive under budgetary pressures.
One cassette, CAN $16.00

Instructor Excellence: Mastering the Delivery of Training
(The Jossey-Bass Management Series)
by Bob Powers, Malcolm S. Knowles (Designer)
From Book News, Inc. , August 1, 1992
A guide for both experienced and novice instructors of adult training programs, suggesting how to prepare for classes, inspire participation, develop presentation skills, use training aids, and evaluate the course's.

> All the above-mentioned publications are available from:
> Practical Management of Canada Inc.
> 6021 Yonge Street, Suite 1106
> Toronto, Ontario M2M 3W2
> http://www.pmci.ca

Training & Development, monthly magazine
American Society for Training & Development (ASTD)
1640 King Street, Box 1443
Alexandria, Virginia, 22313-2043, USA
http://www.astd.org/virtual_community/td_magazine/

"The Training PlayBook: The Game Plan for Training Trainers", is a comprehensive resource based on 20 years of consulting experience. This program leads professional trainers and novices through each step of the training process, including developing objectives, writing lesson plans, evaluating curriculum and preparing sessions. It is sold in concert with Training for Trainers Workshops or as a separate manual.
Price: $299 (U.S. Funds), available from:
Global Training Alliance
521 5th Ave W #401
Seattle, WA 98119
info@globaltraining.com.
WMO Bulletin, Volume 49, N° 2, April 2000.
The theme of this issue is “Continuing education and training in meteorology and operational hydrology”.

“Guidelines for the education and training of personnel in meteorology and operation hydrology”, WMO -N°258, Volume I – Meteorology, fourth edition (preliminary release June 2000).

TRAINING TECHNIQUES AND MATERIALS/TRAINING THE TRAINER

National Weather Service Training Center, Training Techniques (Needs Analysis, Design and Development, Delivery, Evaluation)
http://www.nwstc.noaa.gov/d.MNGNT/TRNGTECH.HTML

National Weather Service Training Center, Train-the-Trainer, A Conceptual Model.
http://www.nwstc.noaa.gov/d.MNGNT/T3Model.HTML

Training supplies, presentation supplies, bags, flip charts products and ideas for presenters trainers, salespeople, doctors, teachers, anyone who does presentations
http://www.trainerswarehouse.com

A best bet for all your training development needs.
Help, Site Wizard, Site Map, Magazines & Newsletters, Products & Demos, Suppliers
http://www.trainingsupersite.com

Video ~ Effective Training Techniques
In this complete program, veteran trainer Martin Broadwell will give you everything you need to train your new trainers, supervisors and managers
http://www.hrtraining.com

101 Games for Trainers: A Collection of the Best Activities from Creative Training Techniques Newsletter by Bob Pike (Introduction), Chris Busse (Contributor)
http://www.amazon.com/exec/obidos/ASIN/0943210380/annalsofimprobab

Training Techniques
Links and Resources. The following links will help you to design and develop training and electronic ...
http://www.internetraining.com/Screen6.htm

Train-the-Trainer: Proven Classroom Training Techniques
How Adults Learn Planning Programs.
http://www.edjones-train-the-trainer.com/ProvenTechniques.htm

On-the-job Training Techniques
To train participants to develop and implement OJT programs.
http://www.qnac.edu.jo/onthejob.htm

Open and Distant Training Techniques for Small and Medium Enterprises. by Paolo Bianchetti, Stefania Manca, Donatella Persico and Luigi Sarti.
http://www.ercim.org/publication/Ercim_News/enw33/bianchetti.html

Training Techniques - Effective Discussions. This information is useful to course instructors and to participants who will facilitate smaller discussions
http://www.usjaycees.org/training_techniques.htm

How Adults Learn
In order to reach a state of Learnativity, you should understand something about how you learn. The following articles will introduce you to some of the most significant things we know about how people learn.
http://209.130.96.48/adultlearning.html

Introduction to Instructional System Design (ISD) - Design Phase Instructional System Development for training, learning, education, development, and performance classes (SAT - System Approach to Training.
http://www.nwlink.com/~donclark/hrd/sat3.html

Instructional Design of Learning Materials, Principles of Instructional Design and Adult Learning. Notes by: Niki Fardouly. The ADDIE Instructional.
http://www.fbe.unsw.edu.au/learning/instruction...n/materials.htm

Instructional Design Methodologies And Techniques Home Page. Be sure to visit the Interactive Sampler of Learning Theorists. This Web site was developed by three Graduate Students.
www.seas.gwu.edu

Links Related to Instructional Design. These links were gleaned from a variety of searches using the keyword/term "instructional design." Marsha Burmeister, Ed.D. Program Professor Instructional Technology & Distance Education (ITDE)
www.fcae.nova.edu

Top Ten Training Resources List
As the Internet grows, so does the need for Internet training. To meet the needs of current and aspiring, Internet trainers, we've put links to some key resources here.
http://www.itcs.com/topten/trainres.html

Learning and Training FAQs. These Frequently Asked Questions (FAQ) postings serve as an on-line resource for people in adult education, training, and human resources. The FAQs address topics related to improving the way people work and learn.
http://209.130.96.48/training_FAQs/

Human Resources Training. Training the Trainer, if you train people, this dynamic program is for you!
http://www.bizhotline.com/html/training_the_trainer.html

Non-US Organizations
There are hundreds of professional organizations dedicated to supporting learning professionals (adult education, training, course development, instructional technology, organizational development, human resources development). Here is a list of the larger non-profit organizations.
http://209.130.96.48/non-us_orgs.htm

Learnativity.com > Learning FAQs > Training 101. This is the first in a series of Frequently Asked Questions (FAQ) postings designed to provide new Training professionals with fundamental information on the field and resources to find more information. Links are provided where available.
http://209.130.96.48/training_101.htm
