

---

## EFFICIENCY

---

Efficiency has long been a topic of considerable interest in the popular press. If you pick up an airline magazine out of boredom as you circle the airport for the fifth time, chances are there will be an article on some aspect of efficiency. Despite this popular interest, however, most professors and students are inefficient. A little formal study of efficiency and some practice can tremendously improve one's productivity.

Most new professors work long hours and still feel they don't have time to do everything they want or need to do. By being more efficient they could do more research and do a better job of teaching. An efficient teacher can do a good job teaching a course in less time than it takes an inefficient teacher to do a mediocre job. It is also important to train both graduate and undergraduate students to become professionals. Engineers are more effective if they are trained to be efficient. We contend that part of this training should be done in school (it does not hurt to be an efficient student either).

Being efficient requires both an attitude and a bag of tricks. We have placed this chapter near the beginning so that the importance of efficiency can be emphasized throughout the book. The bag of tricks will be discussed in this chapter and to a lesser extent throughout the book. This chapter is a considerable extension and revision of Wankat (1987), and it draws upon the books by Lakein (1973) and Covey (1989) for many of the basic ideas.

## 2.1. GOAL SETTING

People need a reward for being efficient. What will you gain if you get the task done well in less time? To achieve what you want, you first need to set goals. If you are serious about developing a more efficient and productive work style, you need to set both short- and long-term goals. Do this for work and leisure. To illustrate, a young professor's lifetime goals may include the following:

- Be promoted to associate professor and then to professor
- Become a recognized technical expert
- Be recognized as an outstanding teacher
- Provide for children's education
- Spend a sabbatical in Europe
- Remain in good health
- Develop a happy marriage

This is a reasonable but certainly not all-inclusive list. Your goals may be different, of course, because only you can develop that list.

A lifetime is, one would hope, a long time. Action plans are easier to develop for shorter-term goals, so a two- or three-year list of goals such as the following may be useful.

- Remain in good health
- Publish five papers in refereed journals
- Be promoted to associate professor
- Take a Caribbean cruise

Even shorter term lists such as semester lists are useful. Achieving just one or two major goals in a semester requires an unusual level of persistent effort. Lakein (1973) and Covey (1989) have much more information and examples on setting goals. In order for this chapter to be useful you need to write down your own goals (and later activities and priorities). Either start now or do the homework when you are finished with the chapter.

Once various goals have been listed, it is time to set priorities. This involves juggling the order of the goals until you find an order which satisfies you now. Don't try to set priorities for all time. Goals are made to be changed. A reasonable choice for a number-one priority is to maintain good health since it makes achieving the other goals much easier.

Lists of goals have the advantage of keeping you focused on the big picture. However, they don't tell what you need to *do*. For this you need a list of *activities* which will help you achieve your goals. For example, the following list will probably help someone achieve the goal of good health:

Stop smoking  
 Lose ten pounds  
 Jog or swim three times per week  
 Control stress and learn relaxation techniques (see Section 2.7.)  
 Have a physical examination

Activity lists can be developed for each of the goals. In some cases a certain amount of ingenuity may be required to develop a list of appropriate activities. When the desired goal requires a decision by others, such as being promoted, it is helpful to determine what the requirements are for achieving this goal. Unfortunately, these requirements are often moving targets, and it is impossible to get a firm commitment on what is required. For instance, the criteria for promotion usually do not list the number of papers required. However, by asking several full professors you should be able to get an approximate idea of the number and type of publications required. This gives you information for your activity lists which can be used in planning the right activity for reaching your goal.

## 2.2. PRIORITIES AND TO-DO LISTS

Once you have worked out goals and activities, you need to set priorities for the activities. Not everything can be done at once. The professor desiring promotion may give that goal a higher priority than taking a long vacation. The long vacation can be seen as a reward for accomplishing the first goal. Professors usually must work on several goals at once. If research is a major priority, the most hours may be put into this activity, but other activities also must be worked on. Maintaining good health requires a steady commitment. At the same time, courses must be well taught. Committee meetings must be attended, and so forth.

Meeting goals is a day-by-day commitment. An ABC system can be used to set priorities (Lakein, 1973). List the important items to do in the near future as A's. Include work items which have to be done such as writing a series of lectures or a proposal. Also include activities which will help you achieve your lifetime goals and which you chose to work on this week. Note that writing a proposal eventually helps you achieve the goal of being recognized as a technical expert. It is also important to include on the A list large, long-term projects such as writing a book. A mix of things that you have to do and things that you want to do makes work more pleasurable. The A jobs should be worked on during periods of peak efficiency. Putting an item on the A list does not mean that you will finish it today or this week or even this year. Instead, think of it as a commitment to spend a minimum of five minutes on the activity. The purpose of this is to break down overwhelming tasks into little pieces to prevent procrastination. The five minutes may grow into several hours of effort once you get started.

The A items can be listed in order of priority, A1, A2, and so forth. Lakein (1973) suggests this ordering, but we've never found it to be necessary. B items are either less important or less urgent. If there is time, you can work on them this week. If not, the B's and perhaps some of the A's will wait for next week. C items are even less important and are held in reserve. Sometimes these items take care of themselves and there is no need to work on them. Priorities

change. A paper due August 15th may be a C in June, a B in July, an A in August, and an A1 on August 14th. Personally, I prefer to make the rough draft an A in June, the final draft an A in July, and finish everything two weeks ahead of time.

It is useful to realize that importance and urgency are not necessarily equivalent. Keeping up with the literature in your speciality is important, but it is rarely urgent. Priorities help you to be sure that these important but not urgent things are done. There are urgent but less important chores such as committee work, writing thank-you notes, and preparing expense reports which must be done. Do these all at one time when your energy is running low and you need a break from important activities. In setting up priorities it is useful to think about *critical paths* for large projects. Think about what needs to be done in what sequence so that the whole project can be completed quickly. This is illustrated in Fig. 2-1 for an experimental research project. It is important to do the preliminary design quickly so that equipment can be ordered. New graduate students often do not realize that it may take from one month to more than a year for equipment to arrive. If ordered early, the equipment may be available when the experimenter is ready for it.

The tools for ensuring that high-priority items are worked on are *to-do lists* and desk *calendars*. A to-do list delineates the activities that you want to work on within a given time period. Good choices are daily, weekly, and semester to-do lists. A semester to-do list, which is the least detailed, includes only major projects such as papers, proposals, and books. This list is glanced at when weekly lists are prepared. A weekly to-do list includes the activities you want to do that week. Many of the activities may be assigned duties. These assigned duties are indirectly related to your lifetime goals since doing them well will help you keep your job and perhaps be promoted. Include some discretionary activities related to your high-priority goals. Also include nonwork activities which are important to reaching your goals, such as swimming three times a week.

Begin the week by listing the highest priority activities. Put these on daily to-do lists on a desk calendar or appointment book. If you don't get to an activity on Monday, work on it on Tuesday. On Friday, check to see what A's haven't been worked on. Either work on them then, or move them to next week's list. You may find that you no longer want to bother listing B or C items since you'll likely always have more A items than you can finish. You also may want to omit routine meetings and class meetings. Routine meetings can be put on a desk calendar or appointment book and taken care of as they occur. Phone calls and letters can also be recorded on the desk calendar. One suggestion is to arrange your schedule so that you have no meetings on Tuesday mornings and Friday afternoons. This gives you a chance to work on items on the to-do list early in the week, and a chance to clean up at the end of the week.

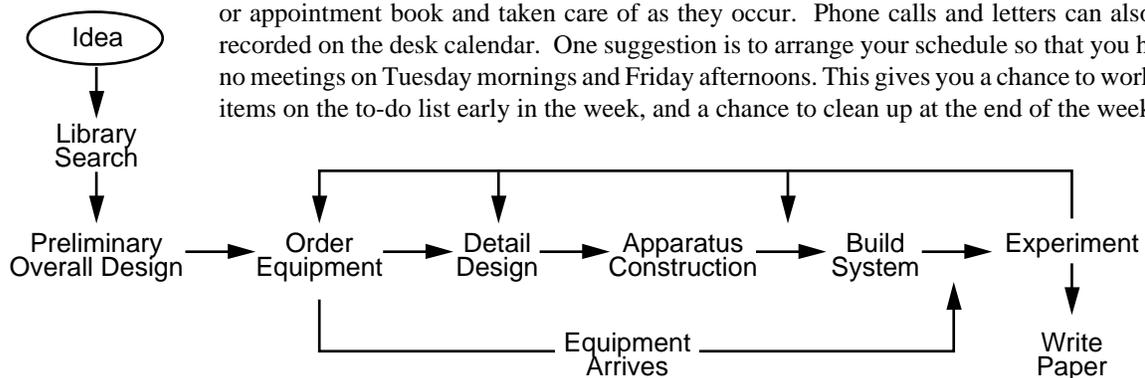


FIGURE 2-1 CRITICAL PATH FOR EXPERIMENTAL RESEARCH PROJECT

One problem with priorities and to-do lists is that you may become too work-oriented and forget to stop and “smell the roses.” If this continues, you will start to burn out. Lakein (1973) suggests writing “smell the roses” on the to-do list. Loosening up on the rigidity of the list may also work. Consider most items on the list as a guide and don’t worry if you don’t work on a particular task. Try to be productive without being rigid about following a schedule. When you become saturated with one project, switch to something else. This is often a good time to initiate people contact or to do nonurgent but important chores.

### 2.3. WORK HABITS

Once we have set goals and developed activity lists to help us reach those goals, we are ready to consider the details of how we do our work. These work habits have a major effect on how efficiently we satisfy our goals and thus are the subject of many books on time management and efficiency (e.g., Covey, 1989; Lakein, 1973; Mackenzie, 1972).

#### 2.3.1. Interactions with People

**Visiting.** Since much of a professor’s time is spent interacting with various people, your work habits involving people are important. You need to determine when and where you work most efficiently by yourself and with others. Some professors prefer to have blocks of time in the morning to work alone, while others prefer the afternoon. For some an hour at a time is sufficient, while for others much longer periods are desirable. Some professors find interruptions very disturbing, while others enjoy them. When you work with others, do you prefer a formal schedule or an informal drop-in policy? These individual preferences are something that only you can determine. A useful way of looking at these individual preferences is with the Myers-Briggs Type Indicator (MBTI) which is discussed in Chapter 13.

Once you have discovered the most efficient way to work, arrange your schedule and develop methods to control interruptions and visitors. Listed office hours are very useful. If a student comes in at another time when you are busy, say, “I only have a couple of minutes now, but I’d be happy to spend more time with you during my office hours.” This approach is most acceptable to the student if you have office hours four or five days a week and you have the reputation of being in your office for your office hours. A second method to control interruptions is to say *no*. It is easier to say no if you have a good reason such as preparing a class in one hour (share this reason with the student), and if you can offer the student an alternate time. If access to your office is controlled by a secretary, he or she can say no to interrupters.

Another method for controlling interruptions is to hide. A second office or an office at home can be a good place to do work which requires solitude. For some reason, most students do not become upset if they can’t find a professor, although they may become very upset if they find the professor and he or she does not have time to talk. Controlling the length of visits is also important. Students and colleagues often want to chat. They may not be busy and may not

realize that you are. When the visit has lasted long enough, stop it. Stand up. Say, “It’s been nice talking to you, but I have to get back to work.” Escort your visitor to the door. This can be done politely but firmly.

**Secretaries.** Unless you have had industrial experience, you probably have never worked extensively with a secretary and have never been in charge of a teaching assistant (TA). Thus working with these people is your first chance to be a manager. The situation is further complicated since you are undoubtedly not the only boss and are probably one of the less important bosses from the viewpoint of your secretary and your TA. How can you best use their capabilities to help both of you do your jobs better?

Peters and Waterman (1982), in their best selling book *In Search of Excellence*, note that outstanding companies obtain productivity through people. A productive professor treats secretaries and TAs with respect. Realize that they have other things to do besides your jobs. Plan ahead and help them plan ahead. Develop a “win/win” atmosphere where both you and the secretary or TA can work efficiently (Covey, 1989). Give your secretary class assignments a day or two before they have to be handed out, not fifteen minutes before class starts. Tell your secretary clearly when they are due. Build in sufficient time so that you can proofread the papers before they are copied. Ask your secretary to proofread the material before it is given to you. Work with your secretary so that he or she understands what you want. For instance, Greek letters may be a mystery to your typist. Explain what they are and point them out on a template.

Try to make your secretary a partner with you even though he or she also works for five other professors. Ask if one time is better for getting a project done than another. Give a warning when there is a big project such as a proposal coming up. If something is not needed quickly, tell your secretary when it is due. (It hardly seems fair to let something sit on your desks for months and then demand that the secretary finish it immediately.) If you consistently give materials on time, then when there really is a big rush, your secretary will reward your fairness with an all-out effort. When someone has really gone out of the way to help you with a project, reward him or her appropriately. Praise never goes out of style. Finally, remember that “please” and “thank-you” are magic words.

Some universities do not provide secretarial assistance to professors because of budgetary constraints. This is a very short-sighted view which squanders the much more valuable professorial resource.

**Teaching Assistants.** Teaching assistants can be extremely helpful to professors, particularly in large classes. However, new teaching assistants often have no experience in grading and they need to be trained. Your goal is to make the teaching assistant a partner in teaching the course. Discuss the following with the TA before the semester starts.

**1 Your expectations.** TAs have a paid job and should be expected to earn their money. Usually their duties start before the semester starts and continue until grades are due. The TA may not realize that he or she has contracted for this time.

**2 Attendance and note taking at your lectures.** Otherwise, the TA will be very rusty in grading and helping students.

**3 Proctoring tests and recording grades.**

**4 Office hours.** Help the TA set required office hours at times that are convenient to both the students and the TA. Expect the TA to be available during office hours but protect him or

her from excessive demands from students at other times.

**5 Grading.** Explain in detail how you want grading done. Remember this is probably a learning experience for the TA also. For the first few assignments grade a few problems to serve as examples. Check over the TA's grading and give feedback so that he or she can improve as a grader. Expect a reasonable turnaround on grading, but tell the TA in advance when a heavy grading assignment will be coming. If students ask for regrades, work with the grader. Listen to the TA's reasons for assigning grades. Try to balance consistency in grading with fairness.

**6 Student interaction.** If laboratory or recitation sections are involved, encourage the TA to prepare ahead of time and to learn the names of students.

**7 Efficiency.** Arrange the TAs workload so that it can be done in the amount of time the person is being paid for.

**8 Communication.** Students who cannot communicate in English should not be used in positions where they will have extensive contact with students.

**9 Personal behavior.** For foreign student TAs you may need to explain clearly that U.S. standards of behavior towards women are different from those in many other countries. Explain these standards and note that they will be enforced.

**10 Training program.** If one is available, encourage or insist that your TA enrolls. If one is not available, consider starting one (Righter, 1987).

**Other Support Personnel.** There are always other personnel in the department who can be helpful to you or who can cause you problems. They include janitors, shop personnel, laboratory instructors, instrumentation specialists, storeroom clerks, business office personnel, computer systems people, and so forth. If you treat them and their work with respect, then they will be helpful. In some departments they have significant student contact, and they may know the students better than do most of the professors. If this is the case, they can be very helpful if you have any problems with particular students.

Whiting (1987) makes the point that a professor must be honorable and honest in all dealings with secretaries, TAs, and other support staff. Thus, do not ask them to do personal favors or anything illegal or unethical. Respect their privacy and what little personal space they have. Ask permission before you borrow any equipment or use any of their equipment such as personal computers. Finally, be sure that your TAs and research assistants also treat the support staff appropriately.

### 2.3.2. Using a Computer

A computer can be an excellent time saver if it is used for activities that require a great deal of time. Professors often spend a large fraction of their time writing. Composing a draft on a word processor or typewriter is much faster than writing it by hand if you can touch-type. Prepare the first draft of all manuscripts on a computer. Make a hard copy and write corrections and additions on it. Then ask your secretary to make the corrections. This procedure will take significantly less time than hand writing the first draft, and it results in a better final manuscript

since revisions are easier to do with a word processor. Your secretary will also find this procedure faster and less work than typing from a handwritten manuscript.

Obviously, efficient use of a word processor requires that you touch-type. The advantages of typing the rough draft of manuscripts are so great that it will pay you to spend the time needed to learn to touch-type and to learn to use a word processor. In addition, all students interested in engineering should be strongly encouraged to learn to touch-type (now called *key boarding*). Even if you know how to touch-type and how to use a word processor, composing on a computer will seem awkward at first. Use an extensive outline as a guide while composing on a computer. Most people can write both quicker and better if they write the first draft as quickly as possible and then spend a significant amount of time revising (Elbow, 1986).

Computer graphics used to be a time sink since the programs were difficult to use, and unless you used a program often you had to relearn it every time. If this is the only software available to you, it would probably be more efficient to have someone else prepare figures. Computer graphics on a user-friendly computer such as an Apple Macintosh is much easier to learn and to remember. In this form computer graphics has become a time saver. However, if someone else is available to do the graphics it would probably be more efficient to give them a rough sketch to be drawn on a computer.

Spreadsheets are starting to be used to a significant extent in engineering education. They are easier to use than programming from scratch and thus tend to be more efficient. Regular use of a spreadsheet will enable the professor to become quite proficient with it, and the spreadsheet will be a time saver. If the spreadsheet is used only on rare occasions, then it is likely to be a time sink instead of a time saver. Students should also be taught to use spreadsheets (see Chapter 8).

In many areas a computer can be a time waster and not a time saver. Programming is a very time-consuming process. Writing programs for classes or developing computer-aided instruction is unlikely to save time because programs have to be polished before being given to students. The use of unpolished programs in a class often results in breakdowns (always at inconvenient times) which the professor must try to fix. It is certainly more efficient to use programs that someone else has written and debugged. If you *must* write your own programs, write fewer programs and spend more time on them so that they work even when abused by students. Setting up files on a computer is a second area where the computer can become a time waster. The problem with files is that they can become an end unto themselves, and they are seldom used for a productive purpose. The files, a C-priority, become more important than the A-priority jobs which the files should support. A third trap which is common for students but not professors involves computer games. Games are fun for relaxation, but don't fool yourself by thinking they are educational. There are many other examples of nonproductive uses of a computer which any computer hacker can list.

### 2.3.3. Miscellaneous Efficiency Methods

Covey (1989), Lakein (1973), Mackenzie (1972) and Roberts (1989) suggest a variety of methods for improving the use of time. One of the most important is to avoid perfectionism. Manuscripts can be revised forever, and the reader will never think they are perfect. At some

point you have to let go and put out a less than perfect, but not sloppy, manuscript. This same reasoning is applicable to other work such as lectures.

A second very important principle is to reward yourself and take breaks. Most people become very inefficient if they try to work all the time. You might recommend to your graduate students that they take at least one day a week off and do no work on that day. This will pay off in terms of long-term efficiency, and overall work production will actually increase despite working fewer hours. Most people also need vacations (even assistant professors). Over a five- or six-year period an assistant professor will probably enjoy life more and get more done if he or she takes at least one week of vacation every year instead of working all the time.

One important efficiency method is to use the same work several times: a process called *piggy backing*. The most obvious application of this is teaching the same course several times. Then the work spent in setting up the course is reused when you teach it the second and third times. Another related application of piggy backing is teaching courses in your research area. Then time spent on research will help you present a more up-to-date course, and time spent on the course will help you better understand your research area. Another example is to prepare a literature review. This work can be published, serve as the literature review of a proposal, be presented as a paper, or serve as the basis for several lectures.

Change your work environment or your task when you get bogged down. Carrying work to the library, college union, or local hangout can provide just the change you need. Switching tasks can also provide a needed break. If proofreading has you down, try reading a technical journal for half an hour.

Another suggestion is to use odd moments to do useful work. Can you do useful work while you commute to work? (Note that relaxation may be the most useful thing to do.) Plan work for trips (see Section 2.4). Take a book or papers to grade to the doctor's office. Figure out what works for you for those ten- or fifteen-minute periods which are not long enough for a "serious" project.

Mail can be handled more efficiently. The general rule is to minimize the number of times you handle it. There is no law which says that you must open junk mail. If you *do* open a piece of mail, try to complete your response immediately. If this is not possible, at least be sure that you do something to move it forward each time you pick it up. Very often a phone call or a Fax will be the most efficient way to take care of mail. You can help your correspondents be more efficient by putting your telephone number, your Fax number, and your computer address on your correspondence.

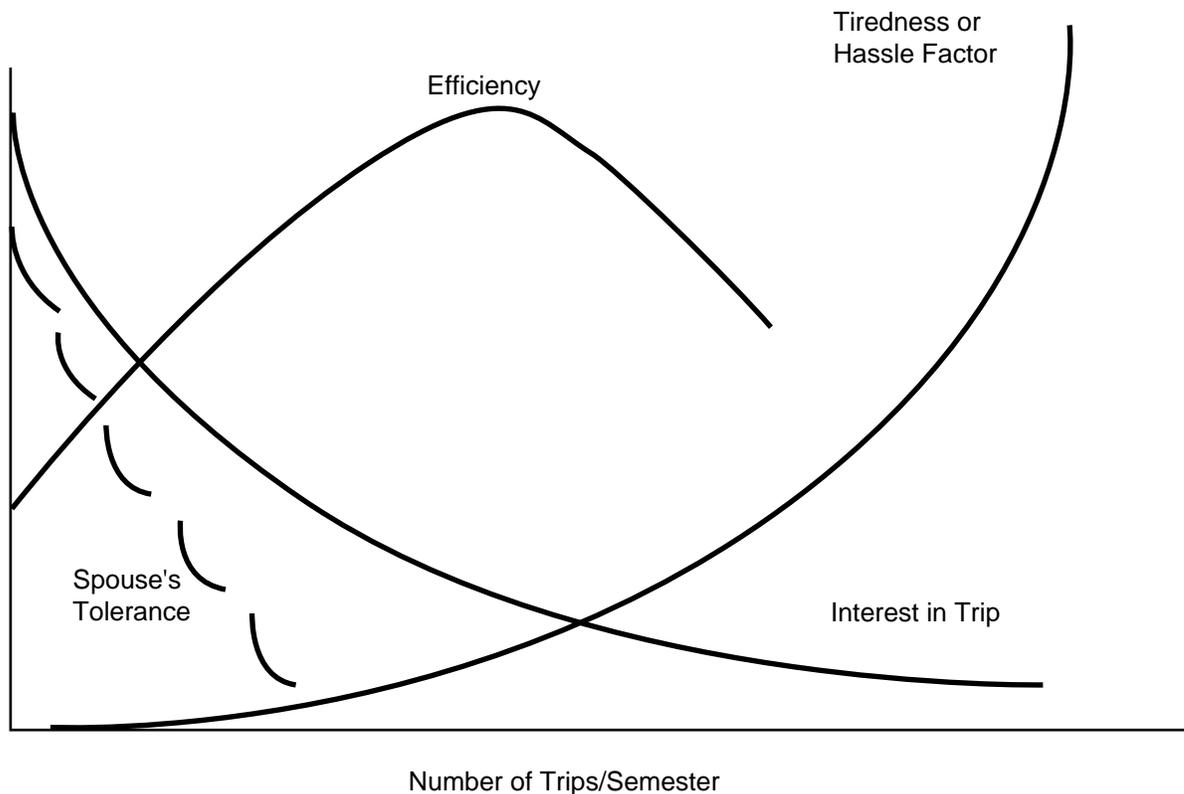
Carry a small notebook or pocket calendar at all times. Then you can write down appointments and transfer them to your desk calendar later. This helps you to avoid missing meetings. The notebook can also be used to jot down ideas, record references, list names of people you meet, and so forth.

## 2.4. TRAVEL

Travel can consume so much time that a separate section on travel efficiency seems to be called for. It can be exhilarating and broadening, but also exhausting. Many of the effects of

travel are shown in Fig. 2-2. The interest and energy generated is very high when you seldom travel (say, once or twice a semester). As you travel more often, the interest in each trip decreases. The first trip to Europe is very exciting; the fifth trip in the same year is a lot less so. Every trip involves a certain amount of hassle in developing plans, buying tickets, arranging for classes while you are gone, and so forth. In addition, when you return you have to catch up on the work you missed while you were gone. These hassles and the work you have to make up lead to a tiredness factor. Cumulatively, tiredness increases as you make more and more trips. The combination of interest and energy generated by the trip and energy drained by the trip is the efficiency curve shown in Figure 2-2. This curve goes through a maximum at a certain number of trips per semester. An additional factor is the effect of your travels on your spouse or significant other. (Even some pets don't like to be left alone.) However, a spouse who travels with you may be more positive about traveling.

There are no numbers on Fig. 2-2 since the values depend upon individual circumstances. If you're not feeling well, one trip may be too many. If your home life is unhappy, getting away may energize you, and the more trips a semester the better. Also, extroverts tend to like traveling more than introverts do, probably because the hassles are not as draining for them. The point of Fig. 2-2 is that there is probably an optimum amount of travel for you.



**FIGURE 2-2** EFFECTS OF TRAVEL

From the point of view of your career and teaching, travel can be either over- or underdone. Not traveling may lead to stagnation, parochialism, and a lack of name recognition for your research. There are several dangers in traveling too much. Certain responsibilities such as office hours, committee meetings, and academic advising really cannot be made up. Professors who are gone too much risk the danger that their classroom effectiveness may decline (see Section 2.5). The important question to ask is, does this travel help me reach my long-term goals? Sometimes travel may help you reach some goals, such as seeing the world, but hinder your reaching other goals such as writing a book. It will probably take one day to catch up for each day you are gone. If you are gone a week, it will take a week to catch up, and that will be two weeks where you do only routine and urgent tasks and don't get a chance to work on important goals. If you decide that you are traveling too much, then learn how to say no to the less important trips. It helps to develop a standard letter for declining invitations.

Once you know that you are going to travel there are some tricks to increasing your efficiency. First, a good travel agent is very important. Not all travel agencies and not all agents within a given agency are equal. Shop around until you find one who will work with you, and then stay with her or him. If you work with a large agency, be sure to get the name of the agent so that you can always contact the same person. Currently, planning ahead, getting your tickets early, and being flexible as to the dates you travel can save money. Registration fees at conferences are lower if you register early.

Use the time spent on airplanes to get some work done. A long flight may represent the longest period of uninterrupted time that you'll have in months. Bring a combination of writing projects and reading, such as a book or some articles to review. If possible, also bring some light technical reading. When the flight is at night after a busy day, you may decide that a review of the day and relaxation are more important goals than doing more work.

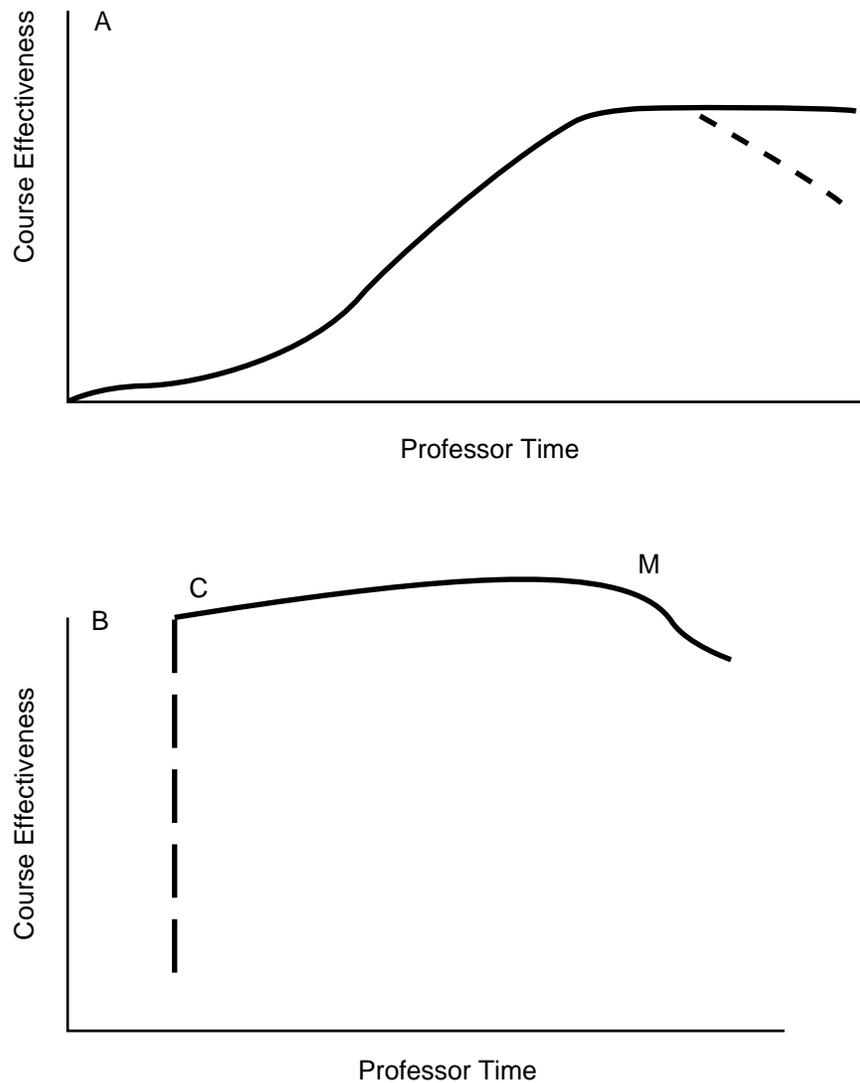
## 2.5. TEACHING EFFICIENCY

Courses can be organized so that they are efficient for the student, the professor, and the TA. First, develop the goals and objectives for the course. Coverage should be reasonable. Then decide upon the basic course organization. The lecture method is most commonly used since it is widely believed to be the most efficient use of a professor's time. This may be true the first time a course is taught, but other methods can be equally efficient the second and subsequent times the course is taught. The other methods may also be more efficient for students since they may learn and remember more material. Develop a tentative course schedule before the semester starts, and hand it out to the students and the TA at the first class session. This allows them to plan for tests and projects. Calling it a "tentative" course schedule gives you flexibility you may need if it becomes necessary to adjust the schedule.

Homework and tests can be developed in efficient or inefficient ways. Solving problems before they are used practically eliminates using problems which either cannot be solved or are too easy. As a rule of thumb, a professor should be able to do the test in one-quarter of the time the students will take. Occasionally using a homework problem or lecture example on a test not only saves time but also emphasizes the importance of doing homework and paying

attention during the lecture (Christenson, 1991). Ask TAs to solve some of the homework problems, but check their solutions. On tests give the TA a solution plus a grading scheme. Requiring written requests for regrades drastically reduces the number of arguments you have to confront.

Preparing for a lecture immediately before the period it will be given ensures that you are fresh. When presenting a lecture given previously, allow yourself one-half to three-quarters of an hour to revise and prepare for the lecture. For totally new lectures or major revisions plan



**FIGURE 2-3** EFFECTS OF PROFESSOR'S TIME AND EFFORT ON COURSE EFFECTIVENESS. A. New professors or new courses. B. Experienced professor with established material.

on preparing a fifty-minute lecture in two hours or less. This prevents Parkinson's law (work expands to fill the time available) from controlling your time. Of course, if you don't understand the material, much more time may be required. Some time can be saved in lecture preparation by using examples from other textbooks (Christenson, 1991). This is preferable to just repeating an example from the assigned textbook. Most new faculty members drastically overprepare and spend much more time than we have suggested here (Boice, 1991).

How much time needs to be spent on a course before it deteriorates? The answer to this depends upon your skill and experience as a teacher and upon your knowledge of the content. Obviously, for new professors and for professors teaching a subject for the first time, more time and effort are required to do a good job. This is illustrated schematically in Figure 2-3a. Our observations indicate this is generally an S-shaped curve similar to a breakthrough curve. Effectiveness increases rather slowly at first and then speeds up as more time is put into the course. As more and more time is spent on the course, effectiveness approaches an asymptotic limit and may actually decrease slightly. As the professor gains experience in teaching and becomes more familiar with the material, the curve sharpens and moves upward and to the left (i.e., to higher effectiveness with less effort).

The hypothetical curve for an experienced professor is shown in Figure 2-3b. Our experience is that there is a very broad range of professorial effort where course effectiveness is quite satisfactory. However, at critical point *C* there is a discontinuous drop in course effectiveness and the course drops below acceptable levels. This drop occurs because teaching, unlike research, is always a "what have you done for me lately" activity. All the rapport and good feeling developed one semester has to be rebuilt the next semester. A professor with a good reputation will have an easier time doing this than a professor with a bad reputation. However, if the "good" professor does not put in enough time or is gone too often, the course effectiveness will crash. Experienced professors can hover in the flat plateau above point *C* and adjust their efforts if they feel the class is slipping. This is somewhat dangerous, particularly if the class is slipping because of too much travel. Note in Fig. 2-3b that experienced professors are more likely to have a maximum, point *M*, beyond which extra effort actually decreases class effectiveness.

In general, students also appear to follow the curves in Fig. 2-3. Fig. 2-3a refers to students who are not experienced learners in a particular area, and Figure 2-3b refers to students who are experienced in a given area.

## 2.6. RESEARCH EFFICIENCY

An excellent, efficient research program will follow many of the same basic principles as a well-run company. The following principles are adapted from Peters and Waterman (1982).

- 1 Be action-oriented. This is Covey's (1989) first habit of effective people.
- 2 Pay attention to the customer. For research the customer is the company, foundation, or government agency supporting the research.
- 3 Within broad guidelines, give graduate students control and responsibility. Do not spell out the nitty-gritty details.

**4** Show respect for each student. One way to do this is to listen more and talk less.

**5** Be hands on and driven by values. Visit the graduate student's laboratory or office. Continually set the basic value of the research group (e.g., "innovation" or "careful experimentation").

**6** Stick to the "knitting." Stay fairly close to your area of expertise but don't continually repeat the same research. Before starting a new project ask, "Do I have the skills, time and energy to do a good job?"

**7** Develop an intense atmosphere with the expectation of regular contributions from every group member.

Supervision of graduate students should aim for a happy medium between too little and too much. Regularly scheduled meetings can prevent excessive procrastination. Occasional visits to the laboratory give the professor a chance to provide intermittent reinforcement. Students work hardest when they feel commitment to a project. This can be attained by having the student develop and work on his or her own ideas. Another method is to ask the student if he or she wants to present a paper at a meeting. A student who makes the commitment to do this will work very hard to complete the paper. Since research efficiency is usually measured on the basis of the number and quality of the papers published, it is important to complete the work and publish the papers.

It is easiest to get results and write publications when you work on new ideas instead of following the well-beaten research track. Thus, time spent on generating new research ideas usually pays off. Many articles and books have been written on creativity and problem solving (Adams, 1978; de Bono, 1973; Wankat, 1982) (see Chapter 5 also). Application of these creativity methods can lead to more efficient research.

A useful method to help you determine semi-quantitatively if a particular project is worth doing is a *cost-benefit analysis*. Cost-benefit analyses can be done for projects other than research, but they are easy to illustrate for projects such as proposals where monetary value is involved. The method is easy to illustrate with an example comparing two proposals. The benefit-to-cost ratio in dollars per hour for writing a proposal can be estimated from

$$\begin{aligned} \text{(Benefit/cost)}(\$/\text{hour}) = \\ \text{(dollars received) (funding probability) / (hours of writing)} \end{aligned} \quad (1)$$

where the hours required to write the proposal is approximately

$$\text{Hours of writing} = k \times \text{number of pages} \quad (2)$$

The value of the proportionality factor  $k$  depends on your speed. The probability of funding is harder to estimate, particularly initially when you have no experience. Some idea of this value can be determined by talking to experienced professors or by talking to the agency. It is desirable to maximize the benefit-to-cost ratio in Equation (1).

Consider two sources of funds: one offering a small amount of money but having a high probability of success, and another offering significantly more money but having a lower probability of success. The following approximate comparison can be done.

**Source A** \$10,000, requiring a ten-page proposal, and having an 80 percent chance of funding:

$$\text{Benefit/cost} = \frac{\$10,000}{10 \text{ k}} \times 0.8 = \frac{800}{k}$$

**Source B** \$150,000 (for 3 years), requiring a twenty-page proposal, and having a twenty-five percent chance of funding

$$\text{Benefit/cost (\$/hour)} = \frac{\$150,000}{20 \text{ k}} \times 0.25 = \frac{1875}{k}$$

On the basis of the cost-benefit ratio alone, source B looks more advantageous. However, there may be other reasons for trying source A first:

- 1 Need to quickly show success in obtaining funding.
- 2 Grant is small but prestigious.
- 3 Grant is for a proof of concept and could easily lead to much more money later.

It may be possible to send very similar proposals to both organizations, but this is ethical only if you inform the agencies of your intention.

A final comment on writing papers. A large fraction of the citations in the literature have some mistake. Therefore, *always check your references.*

## 2.7. HANDLING STRESS

Professors and students often feel a great deal of stress. Modest stress may increase your efficiency and not be harmful to your health. But after some point stress can decrease your efficiency and become harmful. When this occurs is obviously an individual matter. Some people can thrive in an environment which is very stressful for others. An extreme example of this is the response of soldiers to combat. Some soldiers find combat exhilarating, others find it stressful, and some find it so stressful that they break down. In this section three approaches to handling stress are discussed: change of environment, change of perception, and relaxation methods.

Changing the environment may not be easy, but it is a very effective way to reduce stress. Sometimes all that is needed to change the environment is the realization that there are alternatives. For example, some professors find lecturing to be very stressful. These professors can use other teaching methods once they realize there are other methods. A professor who finds the noise from a student lounge to be annoying can ask to be assigned another office. A professor may find that part of his or her lifestyle is increasing stress, and this stress can be reduced by changing lifestyles. Even excessive coffee drinking may increase stress. People with certain medical conditions may find that some weather patterns cause them physical stress. Alleviation of this problem may require moving to another university in another section of the country. Some people find all aspects of a professor's life stressful. Their only solution may be to find a job in industry or in a government laboratory. Often a stressful part

of the environment can be changed only by a major move, and other aspects of the position make such a move undesirable. In cases such as this it is important to learn to live with the stress.

Another way to deal with stress is to change your perception. You do not change the actual incidents but instead change how you feel and react to them. Everyone has a surprisingly large degree of control over how they feel and react to situations and conditions. Some professors feel that they have to be perfect and thus become very upset if a class does not go well or a research paper is harshly criticized. Being upset over these “failures” is not a problem. The problem lies in being so upset that the person is unable to function. Individuals with a need to be perfect will be happier and more efficient if they learn to accept some imperfection in their lives (see Appendix 2A).

A similar problem arises with professors who feel responsible for the actions of others. For example, most professors do not enjoy flunking students, but some professors find doing so to be extremely stressful. They feel that the F is their responsibility instead of the student’s. It is much less stressful and fairer to assign this responsibility to the student where it belongs. Alleviating the problem of assigning yourself too much responsibility is possible by the same methods which work for overperfection.

Another related problem is the *catastrophe syndrome*, that is, believing that a catastrophe will occur whether something happens or does not happen. The something can be rejection of a paper, low teaching ratings, denial of tenure, or whatever the professor wants to name. Admittedly, none of these are pleasant, but they are catastrophes only if they are perceived that way.

There are many psychological methods which can be used to overcome perception problems which increase stress. Many of these methods require the help of a counselor or psychologist. There are some methods such as rational emotive therapy (RET) which can be learned and applied to oneself (Ellis and Harper, 1961, 1975; Ellis, 1973, 1988). Essentially, RET postulates that we think irrational, unhealthy thoughts and it is these thoughts that make us feel bad. The solution proposed by RET is to rationally attack the irrational thoughts and change our thinking patterns. The RET approach is briefly outlined in Appendix 2A.

The perception of stress can also be reduced by desensitization procedures (Humphrey, 1988). Desensitization involves repeated exposure to the stress-causing stimulus, but in a relatively supporting and nonthreatening environment. In a clinical setting the exposure is usually obtained by imagining the stress-causing event. In classical applications of desensitization the stimulus is first present at a very low level, and then gradually the level is increased. This may sound complicated, but it is not uncommon for professors or department heads to apply a similar procedure. For example, a new professor may first teach a graduate class with ten students, then an elective class with thirty students, and finally a required sophomore elective with 150 students. Unless he or she suffers from a more deeply rooted problem, this individual can become desensitized to the stress of presenting a lecture to a large audience. A professor who gives many quizzes in class is in effect desensitizing students who have problems with test anxiety. This method is most effective if the first quizzes are worth a smaller proportion of the course grade than later quizzes, or if a practice test is given.

Relaxation techniques are useful for reducing excessive stress while it is occurring (Humphrey, 1988; Jacobson, 1962; Whitman et al., 1986). There are many methods which are useful in helping one to relax. Physical activity such as jogging, tennis, swimming, or walking is a good way to get away from the pressures of being a professor or a student. Regular weekend

activities, particularly those which get you outside and involve some physical activity, are useful to keep stress from building up. It is important to *get away* and not carry work with you. Professors at least have the advantage that they do not regularly carry paging devices with them. When professors start to carry beepers, stress levels and burnout will increase [see Baldwin (1985) for a discussion of the effects of modern technology on stress].

There are other relaxation methods which are useful on a daily basis. Although less popular now, transcendental meditation (TM) or repeating a mantra works for many people (Humphrey, 1988; Benson, 1974). A westernized version of TM is given by Benson (1974). Various breathing exercises are also useful to help someone who is very stressed relax. These can be as simple as taking a deep breath, holding it for ten seconds, and then slowly letting it out. This simple exercise is useful to hold in reserve in case a student becomes extremely anxious during an examination. Various stretching exercises and methods to relax one set of muscles at a time are also useful and easy to learn. Humphrey (1988) presents a variety of simple exercises which can be used to reduce stress.

Excessive stress can also be very detrimental to students. It is helpful to be able to recognize this and help the student to cope with the stress. The procedures for doing this are similar to those for coping with your own stress. These procedures are discussed in detail by Whitman et al. (1986).

## 2.8. LIMITATIONS

Efforts at efficiency can be overdone, and many things cannot be done extremely efficiently. Most activities which require personal contact with other people have some built-in inefficiencies. Examples include:

- Starting a class period
- Tutoring
- Advising students
- Mentoring graduate students
- Building consensus (e.g., within a department for a curriculum revision)
- Marriage
- Raising children

If you try to do these activities in a very efficient manner, then others may feel rushed and devalued. The net result is a rapid transaction which may minimize your time, but it is not efficient since what needs to get done doesn't get done. A classic horror story which may be true involves a professor who set a three-minute egg timer whenever a student came in to ask a question. After a short period most students stopped coming in, and the professor saved himself time, but he did not help students learn. Professors can limit interruptions by scheduling these personal contacts at specified times of the day. This will help overall efficiency even though the individual interactions are inefficient.

Innovation and creativity in research and teaching tend to be messy and not particularly efficient processes. (It is hard to sit down and say, “In the next ten minutes I will have a brilliant idea.”) The paradox here is that being innovative and creative can drastically increase your overall efficiency even though the processes themselves are inefficient. Once a professor has a great idea for research, actually conducting the research may be relatively quick and easy. In addition, the research may have considerable impact. To a lesser extent, the same is true of creative ideas in teaching. Students enjoy a bit of change and creativity in their classes.

The planning of an entire career does not appear to be an efficient process despite many books and courses on career planning. Many biographies and autobiographies tell of famous people who go through a period of wandering about before they seize upon their life’s work. There may be false starts and failures or successes until they settle down into their great work.

It is useful to separate tactics from strategy. Efficiency is almost always a good idea in day-by-day tactical concerns. An example is preparing for a class. If you want to break new ground or be able to respond to new areas such as developing a new research program or course on superconductivity, it is probably not possible to have an extremely efficient long-range or strategic plan.

Relaxation is necessary to be efficient over long periods; however, relaxation itself almost appears to be the opposite of efficiency. As noted in Section 2.7, we can learn to relax better or more efficiently. During the period of relaxation, it appears that nothing useful is occurring, yet useful things must be occurring. The paradox that we must learn to live with is that only by allowing for inefficiencies can we truly be efficient as professors and as human beings.

## 2.9. CHAPTER COMMENTS

One of the common problems in designing a course or a textbook is that there is no order that really works. There is always some part of the subject which should be discussed before covering the current topic, but not everything can be last. In addition, for motivational purposes it is useful to present a practical part of the course early so that students know why they are studying the theory. Not all aspects of this chapter will be completely clear until other chapters have been covered, and some won’t be clear until after you have had experience as a professor. We decided to put this chapter early to help professors think about being efficient when designing courses. In addition, putting an important chapter early in the course ensures that sufficient time will be devoted to it. This illustrates a second problem in course design: The most interesting and most useful material such as efficiency and creative design is often left until last so that all prerequisite material can be covered first. When this is done, the interesting material is crowded into the end of the semester when there is never enough time and everyone is tired.

Teaching efficiency in class is a challenge. The concepts are simple and often just common sense. The hard part is applying the principles. Perhaps the best approach would be to not lecture but require students to apply one or two principles to their lives. Then three or four weeks later require an informal oral report on the results. We have found that groups of experienced professors are much more attentive and receptive to a lecture on efficiency than graduate students.

## 2.10. SUMMARY AND OBJECTIVES

After reading this chapter, you should be able to:

- Set goals and develop activities to meet those goals.
- Prioritize the activities and use to-do lists.
- Improve your work habits with respect to people interactions, computer use, and other activities.
  - Analyze your travel patterns and improve your time use during travel.
  - Explain how time spent preparing to teach affects course effectiveness, and use methods to improve your teaching efficiency.
  - Improve your research efficiency and apply approximate cost-benefit analyses.
  - Use methods to control stress.
  - Discuss situations when a strict application of efficiency principles may not be the most efficient in a global sense.

## HOMEWORK

- 1 Develop your lifetime goals as of now.
- 2 Develop your goals for the next three or five years, whichever time frame appears more appropriate.
- 3 Develop activities which will help you attain your lifetime goals.
- 4 Develop your activities to help you attain your goals for Problem 2.
- 5 Assume one of your goals is to become a good teacher
  - a Define the term “good teacher.”
  - b Develop your activities to reach this goal.
  - c How will you know when you have reached this goal?
- 6 Develop a semester to-do list. Be sure to include some of your activities to reach your goals on this list.
- 7 Analyze your use of computers. What could you do more efficiently? Develop a plan to increase your computer efficiency.
- 8 Explain why a professor’s effectiveness in teaching a class or a student’s effectiveness in taking a class will crash if some minimum amount of time is not put into the course.
- 9 Learn one relaxation method and practice it every week.

## REFERENCES

- Adams, J. L., *Conceptual Blockbusting*, Norton, New York, 1978.
- Baldwin, B. A., *It’s All for Your Head: Lifestyle Management Strategies for Busy People*, Direction Dynamics, Wilmington, NC, 1985.

- Benson, H., *The Relaxation Response*, William Morrow, New York, 1974.
- Boice, R., "New faculty as teachers," *J. Higher Ed.*, 62, 150 (March/April 1991).
- Christenson, R., "Time management for the new engineering educator," *Proceedings ASEE Annual Conference*, ASEE Washington, DC, 216, 1991.
- Covey, S. R., *The 7 Habits of Highly Effective People*, Simon and Schuster, New York, 1989.
- de Bono, A., *Lateral Thinking: Creativity Step by Step*, Harper and Row, New York, 1973.
- Elbow, P., *Embracing Contraries. Explorations in Learning and Teaching*, Oxford University Press, New York, 1986.
- Ellis, A., *Humanistic Psychotherapy*, McGraw-Hill, New York, 1973.
- Ellis, A., *How to Stubbornly Refuse to Make Yourself Miserable about Anything!*, Carol Communications, New York, 1988.
- Ellis, A. and Harper, R.A., *A Guide to Rational Living*, Prentice-Hall, Englewood Cliffs, NJ, 1961.
- Ellis, A. and Harper, R.A., *A New Guide to Rational Living*, Wilshire Book Company, North Hollywood, CA, 1975. (This and the original edition are classics in the self-help literature.)
- Humphrey, J. H., *Teaching Children to Relax*, Charles C. Thomas, Springfield, IL, 1988. (There are many useful methods for adults in this excellent book.)
- Jacobson, E., *You Must Relax*, 4th ed., McGraw-Hill, New York, 1962.
- Lakein, A., *How to Get Control of Your Time and Your Life*, Signet Books, New York, 1973.
- Mackenzie, R. A., *The Time Trap: How to Get More Done in Less Time*, McGraw-Hill, New York, 1972.
- Peters, T. J. and Waterman, R. H., Jr., *In Search of Excellence: Lessons from America's Best-Run Companies*, Harper and Row, New York, 1982.
- Righter, R., "Training for Teaching Assistants," *Eng. Ed.*, 77 (10), 135 (Nov. 1987).
- Roberts, M., "8 ways to rethink your workstyle," *Psychol. Today*, 42 (March 1989).
- Wankat, P.C., "How to overcome energy barriers in problem-solving," *Chem. Eng.*, 89 (21), 121 (1982).
- Wankat, P. C., "Efficiency for Professors," *Proceedings ASEE/IEEE Annual Frontiers in Education Conference*, IEEE, Washington, DC, 207, 1987.
- Whiting, P. H., "Getting Started: A Potpourri of Suggestions for the New Engineering Educator," *Proceedings ASEE Annual Conference*, ASEE, Washington, DC, 874, 1987.
- Whitman, N. A., Spendlove, D. C., and Clark, C. H., *Increasing Students' Learning: A Faculty Guide to Reducing Stress Among Students*, Association for the Study of Higher Education, Washington, DC, 1986.

## APPENDIX 2A. THE RATIONAL-EMOTIVE THERAPY APPROACH

The rational-emotive therapy (RET) approach will be briefly outlined here. RET postulates an ABC method of viewing human reactions. The *activating experience* A is the outside stimulus that the person reacts to (e.g., bad reviews of a research paper or the acceptance of a paper). Step B consists of the *internal beliefs* which lead the person to interpret what has happened. These beliefs can be rational or irrational. For example, a rational belief is that a rejection is unfortunate since more work will be required, but that the rejection is not a catastrophe. An example of an irrational belief is that a rejection is a catastrophe which must not happen. Eventually, the person experiences an *emotional consequence* C which he or she thinks is caused directly by activating experience A. An example of an emotional consequence C is anger and depression. Thinking that A caused C is irrational. This must be irrational since another person will react to the same A in a very different way and experience a completely different C. The emotional consequence C is caused by the beliefs B which the person has. If

these beliefs are rational, then C will be reasonable (e.g., if the belief is that bad reviews are unfortunate since they will require additional work, then C will be a mild displeasure). If the beliefs are irrational, then C can be an extreme reaction.

Most people have irrational beliefs about something. Examples of irrational beliefs which people subconsciously carry around in their heads are:

- 1 It is horrible to be rejected.
- 2 I have no control over my feelings.
- 3 I must be liked by everyone.
- 4 All my lectures must be perfect.
- 5 It is catastrophic if something I do is not perfect or is criticized.
- 6 All snakes are dangerous and bad.

The amount of disruption these beliefs cause in the person's life depends upon the belief and how strong it is.

The RET approach is a method for combatting the dysfunctional aspects of emotional consequences caused by irrational beliefs. The method involves rigorously analyzing your thoughts to determine the irrational beliefs and to replace them with rational beliefs. For example, suppose you just received a letter from a funding agency rejecting a proposal which you thought was very good. Your first reaction is to become angry and you know that you will be depressed and angry for several days. With the RET approach you first stop and listen to what you are saying to yourself.

Ask, "Why am I angry?" Then listen to your own response which might be, "Because I was turned down." Now the RET approach pushes deeper. Ask yourself, "But why does being turned down make you angry?" Here the response might be, "Because I'm not supposed to be turned down." A further push could be, "Why aren't you supposed to be turned down?" "Because I should be perfect." "And what else?" "Well, everyone should always approve of my work."

The beliefs that one is supposed to be perfect and have everyone approve of one's work are clearly irrational. These and probably other irrational beliefs are causing the anger and depression. RET postulates that the appropriate place to intervene is in the irrational belief system. Continuing our example, you could respond to yourself, "Perfect! No one is perfect. That just is not rational. It's also not rational to expect everyone to like your work even if that work is very good." Now you need to substitute a rational belief for the irrational one. For example, "A rational approach is that it is nice and certainly preferable if your work is good and is approved by everyone. However, it is not a catastrophe if you occasionally do some work which is not up to your high standards or if someone does not like your work. It is unfortunate that the proposal was not funded since you will have additional work to do to resubmit it, but it is not worth becoming angry and depressed over for days."

This approach may sound simplistic or too good to be true. The method does work but requires considerable work and practice. The irrational beliefs have been there for a long time and are usually difficult to eradicate. However, if these beliefs are attacked logically every time they appear, they become weaker. In addition, as one practices RET on oneself, one becomes much more adept at spotting irrational beliefs and at fighting them. Readers interested in this method should read one of the books by Ellis (Ellis and Harper, 1961, 1975; Ellis, 1973, 1988).