

The most common form of teaching in engineering classes in the United States is undoubtedly lecturing, and for many professors lecturing is synonymous with teaching. Lecturing can be an effective, efficient, and satisfying method for both professors and students. Yet many lectures do not satisfy learning principles and are not conducive to student learning. Despite common misuse of the lecture method, a perusal of *Engineering Education*, of *ASEE Prism*, or of the ASEE annual conference program shows few articles or presentations on lecturing.

One of the fundamental principles of engineering is to attack the critical problem which can make the most difference. In engineering education, improving lecturing is arguably the critical problem; and the first focus on improving engineering education at all schools should be on improving lecturing.

We will first consider the advantages and disadvantages of lectures, and then methods for improving content, organization, performance aspects, and interpersonal rapport in lectures. Next, special lecture techniques and special problems for large classes will be explored. Finally, the lecture will be looked at as one component of an entire course.

6.1. ADVANTAGES AND DISADVANTAGES OF LECTURES

Lecturing is a two-sided coin. An aspect of lecturing which is advantageous for an excellent lecturer can be a disadvantage for a poor lecturer. However, practically every disadvantage can be overcome if the professor makes an effort to overcome the problems. The following advantages and disadvantages are gleaned from our experience and from Alexander and Davis (1977), Cashin (1985), Eble (1988), and Johnson (1988). Some of the advantages of lectures include the following:

Audience focus. The lecturer can be aware and responsive to a specific audience so that each student feels that he or she is being talked to as an individual.

Versatile and flexible. There are many variants of lectures, and other teaching methods can be included within the lecture format.

Easily updated. Unlike some other teaching methods, changing lectures is easy and inexpensive. Material which is not otherwise available can easily be included in a lecture.

Low technology. Little can go wrong other than the lecturer becoming ill.

Acceptable and familiar. Some students like lecture because it is usually nonthreatening and they can hide in the multitudes.

Can incorporate learning principles. Those learning principles which are not incorporated into the lecture itself can easily be included in the entire course package.

Live contact. Rapport and immediate feedback to the student are possible.

Professor-efficient. Preparation time can be kept within reasonable limits.

Time-efficient. Can be presented to a large number of students which is an efficient use of the professor's time.

Instructor control. Many professors prefer a teaching style which allows them to have direct control rather than the semichaos which can occur in discussion or self-paced courses.

Anyone can lecture. All new professors have taken lecture classes, and they can copy the procedures. The special knowledge required to lecture is low.

Potentially outstanding for motivation and for conveying information. A professor can convey the interest and enthusiasm that he or she has in the topic. Information can be presented and rearranged in a variety of ways to help students learn.

Lecturing can be **exhilarating** for the professor.

Student learning can be high. If clear objectives are given to students and good support materials are available, research shows that student learning in a lecture course as measured by a content examination is equal to that of other teaching methods (Taveggia and Hedley, 1972). This result refers to the knowledge, comprehension, and application levels of Bloom's taxonomy.

Although anyone can lecture after a fashion, becoming an outstanding lecturer is difficult. If a professor does not know how to appropriately adjust lectures, then each of the advantages listed previously can become disadvantages:

Audience ignored. Poor lecturers push on despite the pain and suffering which is obvious to all but the lecturer.

Inappropriate lecture form may be used. Many professors are unfamiliar with the many variants of lectures and try to force-fit one form onto all circumstances.

Stagnation. Although lectures are easy to change and up-date every semester, many professors don't bother. This is obviously a teacher problem and not the fault of the technique.

Murphy's law. Although less technologically dependent than some other techniques, things can go wrong during a lecture. For instance, the bulb in the overhead projector can burn out or the microphone can malfunction—almost always at the most inopportune moment.

Passivity. Like stagnation of material, acceptability of the method may lead the professor to ignore looking for ways to improve.

Few learning principles may be satisfied. This is often the case in lectures with lots of content and little professor-student interaction. The worst problem is usually the passivity of students in lectures unless special efforts are made to keep them active.

Boredom. A “live” presentation where the professor is boring, speaks in a monotone, makes no eye contact, pays no attention to the students, receives no student feedback, gives no feedback to the students, and is impersonal is “dead.”

Inadequate preparation or overpreparation. Inexperienced professors often spend too much time preparing for lectures, and experienced professors who no longer care may not prepare. One of the problems of lecturing is that there is no mechanism which forces adequate preparation.

False economy. The economic efficiency of large lectures is abused by many universities. Student learning of higher-level cognitive functions would be significantly enhanced in smaller classes with more interactions.

Lack of individualization. Since the instructor controls the pace, it will necessarily be too fast for some students and too slow for others.

Anyone can lecture? Unfortunately, the apparent ease of lecturing hides the fact that lecturing is one of the hardest teaching methods to truly master. In addition, what many professors have seen and are cloning are inferior lecture classes.

When it’s bad, it’s really.... Although they can be outstanding, lectures can also be abysmally bad. In addition, although lecturing is a good teaching method for conveying information, it is not as well suited for some higher-level cognitive tasks such as analysis, synthesis, evaluation, and problem solving.

Extremely stressful. Lecturing can be an emotional trial for some professors. In extreme cases these professors need to find alternate teaching methods which are less stressful for them.

Lack of supporting material. If clear objectives are not given to students and good supporting material is not available, then student learning will be less than with an alternate teaching method which provides these.

Probably more than any other teaching technique, lecturing is teacher-dependent. In short, lectures represent the best and the worst of teaching.

6.2. CONTENT SELECTION AND ORGANIZATION

What content should be included in the lecture and how should it be organized? The experts (such as Davis and Alexander, 1977; Eble, 1988; Lowman, 1985; and McKeachie, 1986) are in surprising agreement about both content and organization. The lecturer should never try to cover everything in the lectures—a major mistake made by inexperienced professors. Remember that students are supposed to spend two or three hours outside of class on homework and readings for every hour in class. Leave a major responsibility to the students. Thus, it is necessary to be selective.

How does the professor decide what to select from the wealth of information and procedures which could be presented? The following ideas can be used to guide the selection of lecture material.

1 Cover key points and general themes. This serves to guide the students' reading and helps them build mental structures. These areas should be reflected in the course objectives and serve to reinforce the importance of these objectives.

2 Lecture on items that students find to be very interesting. Since lecturing is part performance, you might as well give yourself the advantage of choosing topics that students find particularly interesting.

3 Pick especially difficult topics or those that are poorly explained in the textbook. Tell the students that you will focus on these more difficult topics so that they will be able to do the homework better.

4 Discuss important material not covered elsewhere. Particularly in graduate-level courses, important new findings can be included in lectures long before they make it into the textbooks. "The lecture is the newspaper or journal of teaching; it, more than any other teaching, must be up-to-date" (McKeachie, 1986).

5 Include many examples. Students, particularly sensing students, love and need examples. Examples should include problems with numerical solutions and a modest number of short "war stories."

6 Choose material at the appropriate levels of depth and simplicity. Unfortunately, this is easier to say than to do when one has never taught the course before. Once you have taught the course, you can reduce the lecture coverage in areas where most students do well on tests and increase it in areas where students have difficulty.

Once the content has been chosen, you need to put some thought into the mode of presentation. Remember that everyone can use auditory, kinesthetic, and visual modes, and that the more modes employed, the more is retained. Unless special attention is paid to including other modes, the vast majority of lecturing will be in the auditory mode (words written on the blackboard are in the auditory mode). Yet most people prefer the visual mode. In arranging the content, include pictures, drawings, graphs, slides, computer visuals, and so forth. This may require some variation in the content and organization of the lecture.

What content areas can be left to readings and homework? Any content which experience shows students have little trouble with can be left out of lectures. If the textbook does an admirable job of covering particular areas, there is no reason to include this material in the lecture. When fine detail is required to solve problems, it is appropriate to outline the general procedure in the lecture, but leave the details to the textbook. Often, presenting a detailed example is the best way to show students how to do these problems. Whenever material is left out of a lecture, be sure that the students are explicitly told whether they are accountable for it. Clearly written objectives are helpful to ensure that students learn what they are supposed to learn.

A relatively simple organization is often best. Start with an attention-grabbing opener such as a question, a problem, a unique statement of fact, or a paradox. Then provide the students

with advance organization: In other words, tell them what you are going to tell them. It is helpful if this advance organization ties into the last lecture. The main body of the lecture presents the content. In the main body you tell them the information. To finish the lecture, summarize or tell them what you told them. It is helpful to briefly mention what will be covered in the next lecture.

The bulk of the class period is spent on the main body of the lecture. One can organize the main body in a linear, logical fashion. This type of organization is appreciated by the sensing students in the audience and does not prevent the intuitive students from learning the material. A nonlinear, intuitive approach can also be effective, especially for upper-division classes, but is likely to confuse many students at lower levels. It may also be appropriate to present two or three topics simultaneously and to contrast and compare them. For example, transport phenomena can be presented in this form. Students need a hierarchical structure of knowledge, but they learn material best when they do some of the organizing. The result of this is that “a high degree of organization does not seem to contribute to student learning” (McKeachie, 1986). When students are seeing the material for the first time, use an inductive approach. Start with specific, concrete examples that are fairly simple. Use analogies if you know that the students understand the analogous theory. This can lead to much more rapid student comprehension (Meador, 1991). Then lead slowly into general principles. For students who have studied the material previously, a deductive approach can work well. Even in graduate level classes an inductive approach is appropriate if the material is new

The main body should be organized in parts which are clearly delineated. For example, in a lecture using an inductive approach, the first part could introduce the topic with a simple example, the second part could consider a more complex example, and the third part could discuss the general principles. Each part should be ten to fifteen minutes long, and certainly no longer than twenty minutes. Between parts do something else such as ask questions or have a discussion to give the students a short break and make them active. This is necessary because most students have a twenty- to thirty-minute attention span.

In planning the lecture think about the way students learn. If the scientific learning cycle (see Section 15.1) can be incorporated in some of your lectures, many students will benefit. If you consider that your lecture is part of Kolb’s learning cycle (see Section 15.3), then the appropriate activities for periods when you aren’t talking and appropriate homework activities will be clear.

6.3. PERFORMANCE

All lectures are performances. Poor performances lead to poor lectures regardless of the content. Master performances can lead to outstanding lectures if the content and interpersonal rapport are also masterful. The good news is that professors who are content with being “competent” do not have to “perform.” Professors who want to become master teachers do need to develop skills in the performance aspects of lecturing, which are discussed by Cashin (1985), Davis and Alexander (1977), Eble (1988), Engin and Engin (1977), Lowman (1985),

and McKeachie (1986), among others. Since,

Preparation + presentation = performance
we will discuss the preparation and presentation of lectures.

6.3.1. Preparation for the Performance

Actors and actresses start with a script and rehearse. Since a lecture is a play starring one actor or actress, professors also need to prepare for the performance aspects in addition to preparing the content. The main part of the script is the professor's lecture notes. These notes outline the content in a form that the professor finds useful for live presentation. The lecture notes of good lecturers vary from three or four lines on a single index card to a completely written-out speech of several pages. Experiment with different forms of lecture notes to find what works for you. Lecture notes should include specific examples, visuals, and questions to ask students.

One of the paradoxes of lecturing is that the teacher needs to be thoroughly prepared yet appear spontaneous. Underpreparation can lead to fumbling which is obvious to the students. Overpreparation can result in a rigidity that forces the professor to try to cover all topics in a prearranged order despite numerous signs from the audience that the lecture is not going well. Lectures need built-in flexibility so that the performer can adjust to the audience.

Just as playwrights put stage directions in their plays, professors need to include stage directions in their lecture notes. These include announcements and reminders to pass out handouts or to collect homework. Stage directions can also indicate pauses, where to ask questions, and breaks in the lecture for student activities. Alternative paths to provide flexibility can be included in the stage directions. Finally, stage directions can remind the professor to make any last-minute announcements (e.g., "Remember that the project progress report is due next period") at the end of the period. Stage directions are one way that the professor can help to ensure that the lecture is successful.

There is seldom enough time in a professor's schedule for a complete dress rehearsal for every lecture; however, there is time to do some rehearsing ahead of time. Obviously, reviewing and updating lecture notes shortly before the lecture are part of the rehearsal. So is a five-to ten-minute mental preparation immediately before the lecture. If the class is in another building, this preparation can be done while walking over. Review the major points and "psych" yourself up for the lecture. One sign of a professional is the ability to be enthusiastic and interesting for the lecture hour even when the topic is not a particularly interesting one.

Arrange to arrive early at the stage door (the classroom). This allows time to check out the stage. Rearrange seats, clean the blackboard, check the bulb in the overhead projector, and get ready for the class. If the room is too small, too hot, or too cold, complain to the proper authorities. Eventually something may be done to improve classroom conditions. Teaching is often a low-budget production, and the professor must also be the stagehand.

In show business there are always warm-up acts before the main act. Professors can help warm up the audience also. One useful procedure is to write a brief outline of the class in one

corner of the blackboard. This will help students start to think about the class and become mentally prepared to focus on the material. The outline helps satisfy the learning principle of guiding the learner (see Section 1.4). Surprisingly, a handwritten outline is more effective than a typed outline distributed to the class, perhaps because students are more active in processing the information (McKeachie, 1986). A second useful activity is to talk to students. Many students will talk to the professor before or after class but would never dream of coming in for office hours. The professor can be proactive and seek out students instead of waiting for them to come to him or her. Just being in class early sends the message that you are interested in and excited about the class. This interest and excitement can be contagious.

6.3.2. Presentation Skills for Lectures

When a play starts, the house lights dim, the curtain opens, and the audience leans forward attentively. A formal start to a class can focus the students' attention. Professors who use an overhead projector can dim the room lights and turn on the machine. This might be a useful start even if the overhead is used only to start the class with one transparency. Another possibility is to step out of the room to get a drink of water and then make a grand entrance to start the lecture. Some professors start writing on the board a minute or so before the class starts and then signal the class it is time to start by putting the chalk down and turning toward the class. One professor we know takes off his suit coat when it is time to start (and puts it back on to signal when the class is over).

This attention to small items such as how the class starts may seem like nitpicking, but it is this attention to detail that can make the difference between a great and an average performance. Also, not all the changes need to be made simultaneously. Institute a few changes every semester and slowly become more comfortable with performing in class.

Many plays start with an attention-grabbing ploy, such as a murder or dead body. Although killing one's students is not considered good form, professors need to capture attention quickly. Some methods that other professors use include:

- 1 Start with an appropriate comic strip on the overhead projector.
- 2 Start by saying, "I want to talk about next period's test."
- 3 Start with an appropriate newspaper headline such as, "Engineer gives million to university to improve undergraduate teaching."
- 4 Show a photograph of a disaster appropriate to the class. Examples include the collapse of a bridge, a fire at a chemical plant, and a plane crash caused by the failure of a part.

If you occasionally change the type of grabber, the students will wonder what you will do next and this increases their attention.

Once you have the students' attention, you need to retain it while the lecture proceeds. Variety is the key. Change the tone, pace, volume, pitch, inflection, and expressiveness of your voice. A flat, unvarying monotone puts students to sleep, and sleeping students cannot be

learning. Variety is also needed in gestures and in the format of the lecture. Even some variety in where you stand and how you interact with the students can be helpful.

A professor's voice is indispensable in lecturing. Professors who want to improve their speaking skills need to analyze their voices and then work on any problem areas (Lowman, 1985). Listen to excellent speakers such as television newscasters and try to develop a feel for expressiveness, diction, and pace. Then, take the terrifying step of recording and analyzing your speech. Since we hear our own speech in a very different way than we hear the speech of others, no one likes to hear a tape recording of their voice. Listen for particular problem areas such as repeated verbalizations, such as "uh" and "OK", or a strident tone. Repeated words can be reduced once we become aware of the problem. Strident tones can be eliminated by focusing on breathing deeper. Improper articulation is a common problem which makes it difficult for students from different sections of the country to understand a speaker. This problem may be so much a part of the professor's speech pattern that he or she does not notice it even when listening to a tape. Thus it is useful to have someone point out these problems to you in a friendly way. Articulation can be improved by practicing reading aloud (find a small child to practice on).

Another common problem of college professors is failure to project their voices. A good rule of thumb to remember is that you should be speaking to the row behind the last one in the room. But projection is more than merely speaking louder—a practice which usually just wears out the voice. True projection begins with proper diaphragmatic breathing which gives a base for the sound, and then follows with full articulation of the sounds: crisp consonants and full and liquid vowels. Like walking, speaking is too often taken for granted; but improvement in speech, just as in posture, step, and stride, can do wonders for one's personal as well as professional health. Self-help is valuable, but guaranteed improvement is best sought from a professional. If you are serious about improving your speaking voice, consult a professional voice coach (any university with a speech, audiology, or theater department has such an individual).

Beyond speaking the words, the manner in which the lecture is presented is also important. Should you read it verbatim? Use three-by-five cards? Rely on your memory? It is very difficult for people who are untrained to read a lecture effectively. And a lecture can be significantly improved if it is presented spontaneously. As a professor, you have enough command of your material so that notes or topical outlines will suffice to keep you on track. Perhaps the only thing worse than reading a lecture to students is to read the textbook to them. This is guaranteed to earn the professor poor student ratings.

Variety in mannerisms is just as important as variety in speech. Your gestures are also an important aspect of how you communicate, but they must appear natural and not be either wooden or flailing. Most importantly, they must be purposeful, such as those that indicate size, shape, emphasis, and so on; nervous jabs that are out of synch with the message are nonpurposeful and distract the audience. One very effective but underused gesture is to walk into the audience. This gets the students' attention, allows you to make contact with those in the back of a large lecture hall, and provides variety to your lecture. Since the lecture is a performance, you can preplan effective gestures like this. Also practice walking toward the back of the classroom during a class when the lecture is dragging and something needs to be

done to liven it up. Once you have tried an activity a few times, you will have added something new to your repertoire.

Even the barest stage has props. Professors have a table, podium, blackboard, and overhead projector, plus whatever props they bring with them to the lecture. Props can also be used purely for dramatic appeal. Some professors bring in a glass of water and then drink the water while taking a break between two important topics. Props can also be objects brought in for educational purposes. A valve, a circuit board, a new alloy, packing for a distillation column, or different types of crushed rock can all be an informative part of the lecture. Classroom demonstrations during lecture can provide a concrete learning experience and the chance for discovery. The availability of new projection equipment has made it easier for all students to observe demonstrations, and more sophisticated equipment increases student interest (Dareing and Smith, 1991). Demonstrations do require setup time and a practice run before class. These props have a greater impact beyond their educational value alone: They also provide variety and a chance for both visual and kinesthetic learning.

The most important props in most classrooms are the blackboard and the overhead projector. Though commonplace and easily taken for granted, both need to be used effectively. Both tools can be used most effectively (1) as an external memory aid, (2) for emphasis, and (3) for visuals. When the outline is written in one corner of the board or on a transparency, it can be referred to during the lecture to show the students where they have been and where they are going. Thus the blackboard or overhead retains the information and serves as memory. The blackboard can also retain an item that you later want to compare and contrast with another item. Whatever is written on the blackboard or overhead is emphasized, and most students will attempt to copy the material. However, while doing this they may miss what you are saying, so putting too much on the blackboard or overhead is counterproductive. If you have some artistic skill, then the blackboard can serve for visual presentations. But even without such skill, you can show graphs and simple schematic diagrams on the blackboard. For more complex figures, transparencies can be made in advance, and students can be given copies of the figures.

Neither the blackboard nor the overhead projector is the best way to present large quantities of detailed information. Students may spend all their time trying to copy the material. In addition to not listening to the lecture, they invariably make mistakes in copying equations or complex diagrams. The situation is often aggravated when predrawn transparencies are shown in rapid succession. If the content requires that you cover a large number of equations or complex diagrams, hand out partially prepared lecture notes that contain the equations and diagrams and have space for student lecture notes. This greatly reduces students' errors in transmission of information and allows you to lecture somewhat faster. An alternate solution is to change the content selected for presentation. If the goal is to produce engineers who can do abstract mathematical proofs, then the lectures, homework, and tests are rightly focused on this activity. If the goal of the course is to have students become good problem solvers, then it makes more sense to spend time solving problems during the lecture.

The biggest difficulty in using a blackboard is the loss of eye contact while writing on the board. This is less of a problem with overhead projectors, but the lecturer must occasionally glance at the screen to check the message the students are seeing. Blocking the view of the

students may also be a problem with both the blackboard and the overhead projector. In addition, most professors lecture too fast when using overheads. One advantage of the blackboard is that material can be left on some portion of the board so that students can go back and copy something they have missed. Overhead projectors can also retain information if the classroom is equipped with two projectors and two screens. Once one transparency is finished, it should be transferred to the back-up projector. We suggest that new professors try both overhead projectors and blackboards. First, obtain student feedback on what can be done to improve both procedures. Then, select one method to focus on and become an expert with this technique.

Eble (1988) states that the skillful lecturers he observed, “were above all keenly aware of and responsive to their audiences.” Remember that a lecture is a live performance. Watch and read the audience. Are they generally engaged with the material or is their attention wandering? If they are showing signs of boredom, what can you do to shift gears? If someone is clearly confused, try asking if you can help (see Section 6.4.2). The audience provides feedback by both their verbal and nonverbal behavior. On rare occasions the message you have from the students is that everyone is focused on you and you have the class in the palm of your hand. Enjoy the moment and try to remember what you did or what the magic content was so that you can do it again.

When something starts to go wrong, the trick is to observe and respond to the problem quickly. After many failures, we finally realized that continuing the lecture and perhaps talking louder does not work. Perhaps you have overstayed the twenty- to thirty-minute attention span of the students and it is time to go to a group activity or have a question-and-answer session. Clearly shift gears and do something which forces the students to engage the material actively. Consider doing one of the following:

- Ask for student questions.
- Switch to a socratic approach and ask the students questions.
- Ask the students to summarize the most important point in the lecture on a piece of paper.
- Give a short quiz (see Section 6.6.1).
- Do a group activity (see Chapter 7).

After about five minutes of this activity you will be able to switch back to lecturing with a renewed student attention span.

Responding properly to signs of audience problems and preventing such problems before they occur require timing. Timing is an art, but it can be learned. If you are good at telling jokes, then you have a sense of timing which can be used in your lecturing. Essentially, having good timing means knowing the appropriate time to do something. In a lecture it is sometimes appropriate to stop when a student has a question, and it is sometimes appropriate to ask the student to wait until you can come back to that student later. Sometimes the lecturer needs to speed up, sometimes to slow down, and sometimes to pause. When a student becomes a bit aggressive and hostile, sometimes it is appropriate to hash out the problem in class, and other times it is better to do it privately. All of these instances are examples of timing. Good lecturers

and good actors develop a sense of timing with experience. It helps to pay attention to what works and record what doesn't work so that next time the timing can be improved.

Humor can also be part of the professor's repertoire in working with the audience. Cultivate your own sense of style. If you can successfully tell "canned jokes," then use them to start the class or break the routine. If you can't tell a joke, don't. Many professors successfully use comic strips on transparencies to start a class; however, the strip should be appropriate and in good taste. Some professors' style of humor is spur of the moment and based on things that happen in the class. Again, if you can do this successfully, it can help keep the attention of the class. If you can't, don't. Finally, avoid overkill.

A final note about performance: Some people have a flair for being dramatic. A little drama can help keep the class interested. There is an inherent drama and majesty in the ability of theory to predict and occasionally to totally miss the behavior of the real world. Build up to the conclusion and at times slip in an unexpected conclusion. A bit of challenge in the class can be fun for the students, particularly if it is nonthreatening. Ask dramatic questions or make dramatic statements. For example,

- What did X do that made him one of the most revered engineers of his era?
- Was the suicide of Professor Y justified?
- There is one pearl of wisdom in this class which will make you rich and famous if you follow it. Your challenge is to find this pearl.
 - In today's class we will discuss the most misunderstood phenomena in electricity and magnetism.

A sense of timing is needed to let the drama build. Do not answer your question or explain the statement immediately. Let the students search and try to puzzle out the answer. Student learning will be much deeper if they can determine the answer for themselves, even if they beat your telling them by only a minute.

6.4. QUESTIONS

Answering and asking questions is an art in itself. Questions offer an opportunity to work on the content and develop rapport. Students asking or answering questions are active and thus are satisfying one of the learning principles discussed in Section 1.4. Questions also serve as a break in the lecture and allow some students a chance to catch up in their note taking. Finally, the instructor's availability to answer questions is one of the factors that students implicitly include in their overall ratings of instructors (see Section 16.3.2).

6.4.1. Answering Student Questions

We strongly encourage students to ask questions in class. If many students are confused, the professor can clarify the issues for them simultaneously. Thus, during the first class period we make it clear that we want students to interrupt the lecture with questions. Some professors prefer to control student questions and have students ask only at specified times. Pause fairly frequently during the lecture and ask if there are any questions. Then, give the students time to pose an intelligent question. The appropriate length of the pause requires a sense of timing.

When a student asks a question, accept it positively and then rephrase it so that the student can be sure that you understand the question and so that the rest of the class can hear it. Examples of positive reinforcement for asking questions include:

- Good question.
- That's very insightful of you, Karen.
- Bob, you're following me exactly because that's my next topic.
- Good, I was waiting for someone to ask about that.

Restating the student question can be a challenge. When students are extremely confused, they have difficulty even phrasing an intelligent question. Asking a question under these circumstances is an act of bravery (which is one reason the student should receive a positive response). Make your best guess as to what the question is, even to the point of asking the student if that form is reasonably close to what he or she wants to know.

Various responses to the question are now possible. Since students usually prefer either a brief direct answer or an involved direct answer, it's best to give direct answers most of the time. If the question opens up a new topic which will be covered in a few minutes, ask the student to wait, and if not satisfied in a few minutes to ask again. When we use this technique we try to remember to ask the student later if the question has now been answered. The student can be referred to the book; however, this works best if the answer can be found in the book during the lecture and the question is answered immediately. Otherwise, "Look it up in the book," comes across as a very negative reaction to a student's question. The question can be posed to the class to determine an answer. This works well in classes where discussion is commonplace. If the question is quite involved or the student clearly does not understand your answer, ask him or her to see you after class. This is often appropriate when the student wants to see the complete solution to a problem and time is not available to do this. Another response is to ask another question to try to lead the student to the correct response to the original question. Unfortunately, this approach tends to inhibit student questioning since it puts the student on the spot. Finally, if you do not know the answer, the safest response is, "I don't know, but I'll find out." This instructor honesty helps to increase rapport with the students.

6.4.2. Asking Students Questions

Asking questions is a rather different skill than answering questions. There are several advantages to asking questions during class (Hyman, 1982). Questions can provide as a break in the lecture which helps to keep the students active. Questions also provide feedback to the professor and students about what material is being understood. Questions provide the professor with an alternate way to emphasize particular points, clarify difficult concepts, and review material. Rhetorical questions are often useful for this purpose or for highlighting key questions. Questions can be used as examples of possible test or homework questions. They can also be used to start a discussion or to encourage student questions (“If you don’t have questions for me, then I’ll have some for you”). Questions can be used to help maintain discipline or keep students awake. Some professors structure their entire teaching style around questions and use a socratic style instead of lecturing.

If you often ask rhetorical questions, then some sort of signal is needed that the question is for the students. For instance, “Now I have a few questions for you.” Even if you never use rhetorical questions, it’s useful to let the class know that you are going to shift gears away from lecturing. “Let’s take a break from the lecture and try some questions.”

Students and new professors often believe that the questions asked by the professor must be spontaneous. A few are, but most are preplanned. Posing a good, clear question which requires some thought to answer but is not beyond the ability of the students requires some time and effort to prepare. Prepare ahead of time and write these questions in your lecture notes. If a good question arises spontaneously, try it and record it in your notes after class.

What are the elements of a good question? It should be relatively short, clear, and unambiguous. Only one question should be included; that is, do not run a string of questions together. If you want to ask a string of related questions, then ask one at a time and get a response before proceeding. Otherwise, you are likely to confuse the students (Hyman, 1982). The question can be at any level of Bloom’s taxonomy, and if you want students to become proficient at all levels, then you must ask questions at all levels. In some cases you may want to write an equation or draw a figure on the blackboard or on a transparency to frame the question.

In engineering it is appropriate to ask questions which require a modest amount of algebraic manipulation or numerical calculation. Tell the class to take out a piece of paper and a calculator. Then write key elements of the question on the blackboard or use a preprepared overhead transparency. Students can work individually or in groups. Questions can range from very simple single-answer questions, such as unit conversions, to unusual situations where basic principles can be used to obtain an answer to open-ended questions. Wales et al. (1988) give some examples.

Usually, it is best to ask the question of the class as a group and then pause. When a question is asked of the class as a group, no one knows who will answer it and most students will try to develop an answer. If you are using the question to help keep a student awake or to control a disruptive student, then you might want to preface it with the student’s name. Even students who are close to falling asleep will respond to hearing their name. After asking the question, pause. The pause is critical and for most teachers is much too short. It takes time for students to formulate an answer.

There are a variety of ways to field students' responses to questions (Hyman, 1982). If the student's answer is correct, offer praise: "Excellent," or "You're absolutely right." This gives the student strong positive feedback and tells the rest of the class that the answer is correct. If several students are straining to answer, you can call on several without responding to each individual answer. Then respond in general to all of the responses. You can also build on a student's response. "You're correct about the fluid flow. But let's consider the mass transfer in more detail..." The continued detail can consist of explanation by the professor or additional questions.

What if the answer is wrong or partly wrong? For many professors the immediate reaction is a "Yes, but..." type of response. Unfortunately, this sends a negative message to the student. It is better to be more straightforward about those aspects which are wrong. Some possibilities include:

- You're right about aspect X but wrong about Y. Let's explore Y in more detail.
- I think that you have misinterpreted my question. Let's try it again. (Use this type of response only when you really believe the student has misinterpreted the question.)
 - No, I don't think that you have the right idea on this.
 - Explain how you developed that answer.
 - How many students think this is correct? How many think this is incorrect? Why is it correct or incorrect? (These responses should be used occasionally for both correct and incorrect answers.)

Should you call on students who volunteer to answer, or should you call on all students at some time during the class? There are advantages and disadvantages to both options. Volunteers are likely to be more articulate and are more likely to have an answer. In addition, calling only on volunteers makes the class safer for the students, since they know they won't be called on when they don't volunteer. If you call on volunteers, spread out which of the volunteers is called on. Call on a student who seldom volunteers, when he or she finally does volunteer, to help him or her participate in the class. The disadvantages of calling only on volunteers are that some students will never participate in the class and that students who decide not to volunteer may not try to solve the problem independently.

Calling on students at random or with some prearranged rotation schedule keeps all the students "at risk." The professor can force more students to participate, but the anxiety level in the class is likely to increase. In addition, the percentage of wrong answers or "I don't know" answers will increase. If class participation and the ability to answer questions and present arguments in public are important in your class, then some type of strongly encouraged participation is needed. One modification used in law schools is to allow students to put a slip of paper with their name on it on the desk if they are not prepared to discuss that day's class.

Some professors use a modified socratic approach in their lecturing. Short periods of explanation of the material are interrupted by question periods. The professor calls on particular students and makes sure that everyone is called on at least every other period or so. This is most effective in medium or small classes (less than about fifty students). The professor can develop better rapport with the students if each student is called by name. In addition,

professors who become adept at reading students' nonverbal clues can choose to call on students either when they are ready or when they are not ready to respond. This procedure does help most of the students improve their ability to think and respond under pressure, which is a useful ability for an engineer. Depending on the professor's attitude and style, this approach can be either moderately or very threatening to students.

There are gender differences in asking and answering questions (Tannen, 1990). Generally, men are more comfortable speaking in public, while women are more comfortable speaking in private. Thus, the men in the class are more likely to ask and answer questions regardless of how well they know the material. They are also more likely to be willing to challenge the professor. Professors are then faced with a value question. Should they let people keep the roles they have been socialized into or should they try to change them (the men, the women, or both)?

6.5. BUILDING INTERPERSONAL RAPPORT IN LECTURES

Interpersonal rapport is the second dimension in the model of good teaching shown in Table 1-1. Although large lecture classes are not the ideal vehicle for building rapport, a professor can do many things to increase rapport with his or her students.

6.5.1. Student Contact Before, During, and After Lecture

We have already discussed the importance of coming to the lecture hall early. The few minutes before class provide an excellent opportunity to make contact with students even if you and the students have to wait in the hall while the previous class finishes. Greet students by name. For example, "Hi Susan, how are you doing today?" or "John, did you get that problem we were talking about yesterday?" Early in the semester when you don't yet know every student's name, it is not impolite to walk up to a student and ask what her or his name is. Many students will come up before or after class and ask if they can ask a question. Responding in a friendly way using the student's name sends the message that you are friendly and you know who they are—"Yes Bob, what's the problem?" (Note: In our examples we use first names. Some professors are more comfortable and think it is more professional to be more formal and use the student's last name.)

Once the lecture starts there are a variety of ways to make contact with students. The most obvious and direct way is by eye contact. In some cultures it is considered impolite to look a person in the eyes when speaking, but in ours the opposite is true. Establishing eye contact with students not only lets them know that you're aware of their presence but also makes them feel that you are speaking to them and not just at them, whether in lecturing or asking and answering questions.

If a student has come up with a thoughtful question or a clever solution to a problem, share it with the class by naming the student: “Jennifer Watkins has come up with a very interesting paradox that I thought everyone would be interested in.” This shows the student that you really did pay attention and thought that her idea was important. If student presentations are part of your class, you could also ask the student to present her paradox and the resolution to the class.

Recognizing student feelings during the lecture can help increase your rapport with students. For example,

“I know several of you are angry about the test. You felt that you could have done much better if you’d had more time. I agree that the test was a bit long. I’m working on getting more time for the next test.

“This point must be confusing. Can all of you who are *NOT* confused please raise your hand. Yes, I was right, many people are confused.” (Note that a large percentage of students will not raise their hands regardless of the question. Thus, the professor can make most of the class look like they are on one side of the question or the other by changing the phrasing of the question.)

Part of the trick of developing personal rapport in class is presenting a part of yourself in the lecture. We mean doing this in a professional way, not talking about personal problems. Although it does not hurt for students to see you as a real person with a family and with real problems, this realization should come from activities outside the classroom. In class, share with the students your excitement and enthusiasm for the subject, “This is really great stuff.” If you had difficulty learning a topic when you studied it for the first time, share this with the students also. If you will miss a class because of a professional society meeting, share with the class the importance of the meeting and what you expect to learn there.

Another prime time to talk to students is after the class is over. Stick around for a few minutes and answer students’ questions in the classroom or in the hall. If a cluster of students is waiting to talk to you, turn first to the student who rarely says anything in class. This is the student who needs the most encouragement. If there are too many students waiting to talk to you after class, consider shortening the lecture by five minutes to allow more time for informal questions.

6.5.2. Other Methods of Increasing Rapport With Students

There are a number of ways that students can become involved in a lecture class. One method is to have a group of volunteers who meet regularly with the professor to provide feedback (McKeachie, 1986). This is useful in very large lecture classes. The student volunteers can be told to talk regularly to other students and obtain feedback. Then when the feedback is presented to the professor, the volunteers quickly learn that they can be very blunt since they are merely reporting what someone else told them. If the professor is willing to make

some adjustments, this procedure can help class rapport since the students can see that their feedback makes a difference and that the professor cares. Obviously, the professor has the opportunity to get to know the volunteers well. The entire class can also be asked to do a formative evaluation early in the semester, and the professor can respond to these comments (see Section 16.1.).

The professor can increase rapport by being sensitive to nuances in relationships with students. Clearly, the professor has more power in this relationship, but by using egalitarian language in making assignments, he or she can promote student independence (Lowman, 1985). For instance, instead of ordering students to do a homework assignment, the professor might say, “Those of you who do problems 6, 7, and 9 will find that they will help you in Friday’s quiz.” Sharing the course objectives with the students can also make assignments seem rational. Thus, the professor might explain the reason for an assignment, “This reading will help us reach our goal of being able to....”

When possible give the students some choice. Projects can be very effective, particularly for upper-division students, because they give students a choice as to what they do (see Section 11.4). In elective classes students can also be given a choice, within limits, of what material to cover (Wankat, 1981). If the examination date is not carved in stone, students can be allowed to vote on the date. These options give them some control over their studies and increase the likelihood that the professor can become a partner in learning.

Other special procedures can be used to help build rapport, particularly in large lecture classes. These are discussed in Section 6.6. A variety of one-to-one contacts outside the classroom will help build rapport (see Chapter 10). Other aspects of the entire course can fit together so that rapport with students is enhanced (see Section 6.8).

6.6. SPECIAL LECTURE METHODS

One reason why professors continue to lecture hundreds of years after the invention of the printing press is the flexibility of the lecture format. Lectures can be modified to include almost all the learning principles. In this section we will briefly discuss three of the many possible modifications.

6.6.1. Postlecture Quiz

Students need to pay attention, and they need feedback on what they have learned. Both of these principles can be included in a lecture format by regularly giving a short postlecture quiz. One way to do this is to give a quiz on technical content during the last ten minutes of class (Peck, 1979). Since the quiz covers material that has just been presented in the lecture, open book and open notes are preferable. Usually the quiz will consist of one short-answer problem which can be solved in a few minutes. The extra time is necessary since students who have just learned the material will be inefficient problem solvers. Of course these quizzes do not replace the need for longer problems in homework assignments and for a few longer tests.

In large classes daily quiz grading can become a significant burden. This burden can be reduced because less homework will need to be graded since the quiz provides the practice that one homework problem would. As a result, one less homework problem can be assigned each day. Also, if the professor is satisfied with awarding no partial credit, a multiple-choice problem can be used. This greatly decreases the grading chore. When there are numerical answers, a method for developing multiple-choice tests which eliminates many of the drawbacks of multiple-choice tests is presented in Section 11.1.3. To start the next period the professor can spend a minute or two going over the solution to the quiz problem and use this as a springboard for discussion. The next lecture will then build on this base.

This type of approach has several advantages. Since the students know that they will be tested at the end of the period, they will pay attention to the lecture and may even read the textbook in advance. They will also ask questions during the lecture because they know they cannot wait until they get home to puzzle out a confusing point. The students also practice every class period, which requires them to be active, and then they receive feedback either immediately or in the next class period. The professor also obtains feedback immediately and knows if the students are learning the basic material. The very frequent quizzing reduces the importance of each quiz and thus reduces test anxiety. Although the professor loses about ten minutes each class period for presentation of new material, some of this is gained back since less frequent hour examinations need to be given. The large number of quiz scores makes grading at the end of the semester easier, and every student knows where he or she stands in the class.

Obviously, this procedure can be varied significantly while retaining the advantages. Some of the quizzes can be assigned as group efforts, or quizzes can be given every other period instead of every period. A short derivation or essay problem can be given instead of a numerical problem. And occasionally the quiz problem can be a review problem instead of a new problem. If the students do very poorly on one quiz, the quiz can be repeated. An alternative procedure called the “one-minute quiz” has been widely adopted in nontechnical areas. In a one-minute quiz students are asked to write one sentence answering one question or some variation of it: “What was the most important concept covered in lecture today?” This can be open book and open notes and, if desired, open neighbor. A one-minute quiz actually takes a few minutes. It has many of the advantages of a problem-solving quiz and can be used as a replacement on days when you do not have time to prepare a quiz.

6.6.2. Guest Lecturers

Guest lecturers can broaden the viewpoint of any course. If the world expert on a topic has an office next door to you, perhaps you could invite him or her to present one lecture. Engineers from industry can give an industrial flavor to presentations that most professors cannot duplicate. Such lectures from an industrial perspective can be valuable in any engineering class and not just in design courses. Many universities also have “old master” or “outstanding

alumni” programs which invite interesting people back to the campus. These individuals are delighted to talk to students, and students usually appreciate the break in the routine provided by guest lecturers.

Ideally, a guest lecturer will integrate his or her presentation neatly into the course (Borns, 1989). For example, an engineer from industry could come in and talk about the design of heat exchangers at the point where the students are ready to cover this material and will benefit from the engineer’s expertise. If the guest’s lecture is to be integrated into the course this tightly, the professor needs to be sure that it is clear what the students can do and what is to be covered. Give the lecturer copies of the syllabus and reading assignments so that he or she can develop a lecture at the appropriate level. If any special props, such as a microcomputer, will be needed, be sure that everything is available and in working order.

Several years ago one of the students in class was the host to an old master. The student asked if the old master (the CEO of a major chemical company) could talk to the class for one period. Although this talk would not be integrated into the class lectures and course topics, we agreed. It turned out to be a rewarding experience. The students were interested and asked many intelligent questions. The old master enjoyed making his presentation and made several interesting points about an engineer’s life in industry and about the importance of courses in school. Although one period of content was “lost,” the students gained more than they lost. Now we take advantage of special opportunities like this once a semester, even if the guest lecturer does not talk about the course content.

Guest lecturers can be wonderful or horrible, and they need to be selected carefully. Find someone who has the special expertise that you want; then check around to find out how good a speaker the person is. Once you have found someone who does a good job, invite them back.

In general, the professor should be present when a guest lecturer speaks. This sends a message to the students that the material is important; furthermore, the professor may learn something. An exception occurs when the professor finds someone to substitute while he or she is away on a trip. Substitute lecturers usually cover the normal course material. Be sure to tell the substitute exactly where you stopped the period before, and afterward find out how much he or she covered. Delineate for the substitute exactly what material should be covered. The best substitute to use is a professor who teaches the same course in different semesters. If you arrange to trade substitutions, the workload tends to even out, and no one feels taken advantage of. Often the class TA is asked to present a lecture while the professor is out of town. This can be a good experience for the TA, but not necessarily for the class. Be sure to sit down with the TA ahead of time and go over the content you want covered in detail. If the TA regularly attends the lecture, he or she will not be rusty. After you return, discuss the TA’s lecture with the TA so that the lecture can be a learning experience for that person. Another practice, once common, was to load all of the substitution work on the assistant professors in the department regardless of their teaching areas. Since this was obviously somewhat unfair, one hopes this practice is gone forever. Regardless of who does the guest lecturing, be sure to thank them in writing for their efforts. If the students comment on how much they enjoyed the lecture, be sure to mention that in your letter.

6.6.3. The Feedback Lecture

The feedback lecture is a technique developed by Osterman at Oregon State University (Osterman et al., 1985). In this approach students first receive a study guide that outlines how they should prepare for each lecture. Then during the lecture they receive a lecture outline as a further guide. The professor lectures for roughly twenty minutes. Small student groups then discuss an important question and turn in a response sheet. The professor briefly discusses the discussion question and then lectures for the last twenty minutes of the period. Homework assignments provide further practice.

This procedure formalizes the use of many learning principles. Students receive clear objectives in the study guide, and their learning is carefully guided by the study guide. The lecture outlines help them organize the material. The group activity in the middle of the lecture requires that students be active and makes the class more cooperative. Feedback occurs from other students in the group discussions and from the professor both during the group activity and after the response sheets are turned in. Some teaching of students by other students often occurs during the group discussions. The discussion questions are chosen to be particularly thought-provoking to pique the students' interest.

Such a formalized procedure obviously requires a fair amount of advance preparation, so it's unlikely the professor will arrive in class unprepared for the lecture. This method also motivates students to prepare for each class since they know that they will have to do something in each class. Students are thus less likely to procrastinate. Obviously, components of the feedback lecture and the postlecture quiz can be combined in a variety of ways.

6.7. HANDLING LARGE CLASSES

Very large classes (more than 100 to 150 students) have some special characteristics which make them different from small classes. The challenge for the professor is to make student learning as close to equal to that in a small class as possible. Our discussion of handling large classes leans heavily on the papers by Hickman (1987), Kabel (1983), and Middleton (1987), and on Johnson's (1988) book.

Large classes require more preparation, more structure, more formalized procedures and more rules than small classes. In many ways good teaching is good teaching regardless of class size, but unfortunately, large classes magnify any problem. Consider preparation. If several hundred copies of a handout are to be distributed, the professor cannot wait until half an hour before class to have the copies made. So more preplanning is required. Arrangements must also be made to distribute the several hundred copies efficiently; thus, the professor must assign the TAs and the secretary the responsibility of being in class to help with these duties. The professor's lecture preparation must also be thorough. In small classes professors quickly develop rapport with the students, and the professor can come in less than fully prepared on occasion. In large classes inadequate preparation is all too obvious and students are much less forgiving.

Large classes need to be more structured. The syllabus needs to be detailed and available on the first day of class. Examination dates *must* be listed. In effect, these dates become a contract with the students and it becomes quite difficult to change them without causing some students major problems. The textbook must be ordered early and needs to be more carefully selected since many students will rely heavily on it. Course supplements may be necessary and have to be prepared well in advance. The grading scheme needs to be formalized and set forth at the beginning of the semester. Since there will be students that the professor does not know well, grading becomes more impersonal. Rules for missed examinations and late assignments need to be stated and followed. There are likely to be more problems with uninterested students talking, reading a newspaper, or sleeping. Formal rules are required so that the students know what is acceptable behavior. An attendance policy needs to be set. Since there is a good correlation between attendance and grades, attendance should be encouraged. Even if attendance is not required, it is still useful to keep track of who attends since poor attendance often explains poor grades, and poor attendance always reduces the professor's tendency to be lenient in grading. The best solution is to assign seats and have a TA take attendance.

Unfortunately, increases in class size often do not mean an equivalent increase in the number of TAs. When this problem occurs, there must be a decrease in the number of items graded. It is possible to grade only a subset of the homework assignments and to use multiple-choice problems for parts of tests. It may also be possible to get undergraduate graders to do part of the grading (Kabel, 1983). Just keeping track of grades becomes a burden with large classes. Use an electronic spreadsheet and periodically post the current scores for every student by student number. Make it the students' responsibility to check for clerical errors.

Cheating is more of a problem in large, impersonal classes (see Chapter 12). Thus, more care is needed in administering the examinations (see Section 11.1.4). It may be necessary to have two copies of the test if the class is too large for students to sit in staggered seats. Care must be taken that all tests are collected and that there is no cheating during the chaos of hand-in time. Uniformity in grading is very important, and each problem needs to be graded by a single person. Rapid feedback is important, but more difficult to achieve in large classes. Written regrade requests are a necessity (see Section 11.2.3).

Small classes, particularly those with fewer than fifteen students, develop interactions between students and between the professor and students with very little formal effort by the professor. This is not true in large classes. A structured period for interactions needs to be provided in the professor's lecture plan, either by small group discussions or a question period. Informal meetings with the professor before and after class become more important, although not all students can be accommodated. Some type of formal procedure such as a seating chart or photographs of every student is required if the professor is to learn the students' names. Close rapport with students is essentially impossible if the professor does not learn the names of the students.

Students in large lectures can be assigned seats in blocks corresponding to their laboratory or recitation sections. Students feel less isolated since they see the same classmates more often. It is worthwhile to set aside two minutes early in the semester to have students formally introduce themselves to the students they are sitting next to. If cooperative group activities are used (see Section 7.2), the students will be working with a group of students they are familiar

with. The laboratory or recitation section TA can also attend the lecture and sit with his or her students. This provides someone close by to answer questions. And it will tend to reduce disruptions since there is a person in authority close to each student.

Overall, teaching large classes is much more of a challenge than teaching small classes. Small classes can be quite a bit of fun, but teaching large classes is hard work. To do outstanding teaching in a large class is the mark of a master teacher—a rare professor.

6.8. LECTURES AS PART OF A COURSE

We should never forget that lectures are only a part of the entire course, and it is the entire course which determines how much students learn and what their attitudes will be. It is important that appropriate learning principles are satisfied for the entire course, but it is not feasible to satisfy all of them in the lecture alone. We will discuss the list of what works from Section 1.4 and consider how each item can be satisfied in a lecture-style course.

The course objectives can be covered in lectures. Probably the most effective way is to hand out a sheet of objectives for each section and discuss them in the lecture. This helps guide students. The lecture is the appropriate place to develop a structured hierarchy of material and the most appropriate place to use visual images. The textbook serves as a useful adjunct for these two tasks.

Although a modest amount of practice and feedback can be provided in a modified lecture, homework and tests serve best for providing practice and feedback. Even if homework is not graded, it is still necessary to provide feedback. This can be done by making solutions available to students.

An attitude of positive expectations will be shown by the way the professor presents the lecture and the assignments. It is also conveyed by the TAs when they mark papers and talk to students. This attitude needs to be conveyed in all aspects of the course.

Student success can be obtained first by enforcing reasonable prerequisite requirements, second, by having homework problems of graduated difficulty, and third, by providing sufficient help for students who need help. Making the class more cooperative can also help ensure success. The class can be made more cooperative by requiring students to work in groups during class and by encouraging group work for homework. If this is done, the homework grade should be a modest portion of the course grade. Group work also ensures that there is some opportunity for students to tutor other students.

Every lecturer should show enthusiasm and the joy of learning during lectures. With a little effort thought-provoking questions can be included in the lecture, in group work, and in some of the homework and test problems.

Individualizing the teaching style is difficult in a lecture, but quite a bit can be done by teaching small parts of the course in a form that will appeal to different learning styles. For example, visual and kinesthetic material can be used in addition to the usual auditory presentation. Lectures plus homework can be arranged to encourage students to go through all four steps in Kolb's learning cycle. (See Section 15.3.) Some advance organizers can be used

to help global learners.

In addition to satisfying these learning principles, it is important that the students feel that the professor is accessible for questions and that the grading scheme is fair. Accessibility for questions includes answering questions both in and out of class. In-class questions can be supplemented by the professor being available both before and after class, and by having a reasonable number of office hours. Since some students are more comfortable talking to TA's, the TA's should also have office hours. Fair tests and grading can be ensured by testing on the objectives (see Section 11.1.1) and by being very careful that grading is uniform. The total course workload should be challenging but not outrageous.

If your class includes all these aspects, it will be a good class even if you are not the most polished lecturer in the world.

6.9. CHAPTER COMMENTS

We have devoted much more attention and space to lecturing than we will any other teaching method. This stems from an “if you can't beat them, join them” attitude. Most professors use some form of lecturing, so we wanted to do everything we could to ensure that lecturing is well done and satisfies learning principles. Lecturing is both the best and the worst teaching method imaginable—it all depends on the skill of the professor.

6.10. SUMMARY AND OBJECTIVES

After reading this chapter, you should be able to:

- List the advantages and disadvantages of the lecture method of teaching.
- Discuss how one selects the content and organizes a lecture. Use these principles to prepare a lecture.
 - List the performance characteristics of a lecture and determine how to improve your lecture performance.
 - Discuss procedures for answering and asking questions and practice improving your questioning skills.
 - List what can be done to develop rapport with students during lectures.
 - Discuss various modifications of lecture methods and explain how these modifications help lectures satisfy learning principles.
 - Explain how large classes are more challenging than smaller classes and discuss what needs to be done differently in large classes.
 - Put lectures into the context of the entire course and explain how a lecture course can fit together to optimize student learning.

HOMework

- 1 Professor X uses the lecture method. List four problems to be aware of and briefly discuss solutions which will allow him to satisfy learning principles.
- 2 Consider one of the best lecturers you've ever had. Describe four qualities that made his or her lectures exceptional.
- 3 Pick one class period in a specific undergraduate engineering course. Select and organize the content to be covered in this one lecture.
- 4 Write lecture notes for the lecture in problem 3. Include stage directions and questions for the students.
- 5 For the lecture in problem 3, consider what methods you will use to keep the students active. Determine if one of the special lecture methods discussed in Section 6.6. would be appropriate. Explain.
- 6 Make a list of performance characteristics which you think are desirable in a lecture. Make a list of what you actually do. (It may be necessary to have a few students help with this list.) Develop an action plan to make the two lists approach each other.

REFERENCES

- Alexander, L. T. and Davis, R. H., "Choosing instructional techniques," *Guides for the Improvement of Instruction in Higher Education, No. 11*, Michigan State University, East Lansing, MI, 1977.
- Borns, R. J., "Professional guest lecturers," *Proceedings ASEE Annual Conference*, ASEE, Washington, D C, 168, 1989.
- Cashin, W. E., "Improving lectures," Idea Paper No. 14, Center for Faculty Evaluation and Development, Kansas State University, Manhattan, KS, 1985.
- Dareing, D. W. and Smith, K. S., "Classroom demonstrations help undergraduates relate mechanical vibration theory to engineering applications," *Proceedings ASEE Annual Conference*, ASEE, Washington, D C, 396, 1991.
- Davis, R. H. and Alexander, L. T., "The Lecture Method," *Guides for the Improvement of Instruction in Higher Education, No. 5*, Michigan State University, East Lansing, MI, 1977.
- Eble, K. E., *The Craft of Teaching*, 2nd ed., Jossey-Bass, San Francisco, 1988.
- Engin, A. W. and Engin, A. E., "The lecture: Greater effectiveness for a familiar method," *Eng. Educ.*, 368 (Feb. 1977).
- Hickman, R. S., "Effective teaching in large engineering sections," *Proceedings ASEE Annual Conference*, ASEE, Washington, DC, 211, 1987.
- Hyman, R. T., "Questioning in the college classroom," Idea Paper No. 8, Center for Faculty Evaluation and Development, Kansas State University, Manhattan, KS, 1982.
- Johnson, G. R., *Taking Teaching Seriously: A Faculty Handbook*, Texas A&M University Center for Teaching Excellence, College Station, TX, 1988.
- Kabel, R. L., "Ideas for managing large classes," *Eng. Educ.*, 80 (Nov. 1983).
- Lowman, J., *Mastering the Techniques of Teaching*, Jossey-Bass, San Francisco, 1985. (This book has extensive sections on lecture presentations.)

- McKeachie, W. J., *Teaching Tips. A Guidebook for the Beginning College Teacher*, 8th Ed., D.C. Heath, Lexington, MA, 1986.
- Meador, D. A., "Parallel learning curve," *Proceedings ASEE/IEEE Frontiers in Education Conference*, IEEE, New York, 136, 1991.
- Middleton, C. R., "Teaching the thundering herd: Surviving in a large classroom," in Shea, M. A. (Ed.), *On Teaching*, Faculty Teaching Excellence Program, University of Colorado at Boulder, Boulder, CO, 13—24, 1987.
- Osterman, D., Christensen, M., and Coffey, B., "The feedback lecture," Idea Paper No. 13, Center for Faculty Evaluation and Development, Kansas State University, Manhattan, KS, 1985.
- Peck, R., "Examinations as a method of teaching," *Chem. Eng. Educ.*, 10, 76 (Spring 1979).
- Tannen, D., *You Just Don't Understand*, Ballantine Books, New York, 1990.
- Taveggia, T. C. and Hedley, R. A., "Teaching really matters, or does it?" *Eng. Educ.*, 546 (March 1972).
- Wankat, P. C., "An elective course in separation processes," *Chem. Eng. Educ.*, 15, 208 (Fall 1981).