

TEACHING METHODOLOGY
(Adapted from UC Berkeley Chemistry TA Handbook)

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If you've never taught before, this section will contain all you've ever wanted to know about teaching--and more. Hopefully, these articles will seem more relevant and helpful after you've had some experience teaching. It will help to reread portions in this chapter from time-to-time after you start teaching.



A. BASIC TEACHING PRINCIPLES¹*Stimulate Attention*

Try to use a variety of methods in presenting materials: lecture, discussion, question-and-answer, demonstration. Modulate your tone of voice, give several different examples, have a capable student work a problem on the board.

Keep Materials Relevant

Stimulate student interest in material you present: relate it to daily living, the biological system, future course topics or exams...



Chapter 7. THE STRUCTURE OF THE NUCLEUS OF THE ATOM
 "What?" exclaimed Roger, as Karen rolled over on the bed and rested her warm body against his. "I know some nuclei are spherical and some are ellipsoidal, but where did you find out that some fluctuate in between?"
 Karen pursed her lips. "They've been observed with a short-wavelength probe . . ."

Check Prerequisites

Learning success or failure depends on the students' background. After determining the prerequisite basic skills and concepts required for a new learning task, determine the students' level of preparation by informal questioning. Refer student to proper review materials.

Stress Practice

Active, relevant practice aids the learning process. Encourage students to participate in discussions, to suggest a plan of attack for solving a problem, to answer questions about the application of principles, to give examples, to solve extra (relevant) problems, etc. In a one-to-one tutoring situation, have the student do the writing.

Encourage Independence

Gradually withhold your hints and suggestive questions during help sessions. "Spoon-fed" students could face difficulties during exams.

Remember Your Role in Modeling

Students will learn from the (good) example you set in:

- a) Problem solving
- b) Lab technique
- c) Safety habits, etc.

Allow Open Communication

Be clear about what you expect of the students, then allow them to ask questions.

Establish a Conducive Learning Environment

- a) Keep labs neat and orderly
- b) Reward students' efforts (by recognition)
- c) Give students prompt feedback to lab work, exams, homework, questions.
- e) Avoid hasty or "smart" remarks at the expense of others.

HAGAR THE HORRIBLE



B. QUESTIONING SKILLS²

Rationale

As a Chemistry teaching assistant, you will ask questions for a variety of specific reasons. You may want to find out what your students have learned in lecture about a certain subject. You may want to find out how well your students have prepared a lecture or laboratory assignment. You may want to use questions to guide a student in solving a problem in a classroom or laboratory setting. In general, as a chemistry teaching assistant, you will frequently encounter teaching situations in which asking effective oral questions is your most important teaching skill.

Level of Questions

The kinds of intellectual skills your students will develop vary in complexity. Sometimes you will be satisfied that a student simply know (i.e., has memorized) a fact. At other times, you will expect more sophisticated reasoning. For example, you may expect students to use evaluative criteria in selecting among two or more synthetic routes to a compound.

A system of classifying educational goals according to a hierarchy of intellectual skills was developed in 1956 under the editorship of B.S. Bloom. In this hierarchy, six broad categories of educational goals are established. These are:

1. Knowledge -- simple recall of facts.
2. Comprehension -- ability to translate into one's own words; use a given equation to solve a problem; translate a literal statement into an equation.
3. Application -- apply concepts to a specific situation; recognize and solve a problem where the equations are not given.
4. Analysis -- involves all that application does, and also requires that students recognize component parts within material; distinguish relevant from extraneous material; distinguish fact from hypothesis.
5. Synthesis -- requires that students assemble components into a form which is new to them; design a research plan; devise a synthetic scheme.
6. Evaluation -- the ability to judge the value of materials in terms of internal and external criteria.

It is much easier to list these categories than to gain enough experience to use them effectively. As you question your students, you will want to keep in mind that there are different levels of questions. If most of your questions are at the knowledge level, many students quickly become bored and pay no attention. If most of your questions are at the synthesis levels, many students will be unable to participate and will quickly become discouraged.

Examples:

1. Knowledge: State the atomic number of oxygen.
2. Comprehension: Define the term "exothermic". Cite two examples of exothermic reactions.

3. **Application:** A student took a pink carnation and bleached it by placing it in a water solution of sulfur dioxide. Next, he took the bleached carnation and immersed it in hydrogen peroxide. The original color reappeared. Explain the sequence of observations.
4. **Analysis:** In the absence of gasoline, identify the products one expects from the thermal decomposition of tetraethyl lead.
5. **Synthesis:** Outline a possible scheme for converting coal, sulfur, air, and water into an asthma medicine.
6. **Evaluation:** Assume you are in a position to decide where limited financial resources should be spent in terms of developing the "breeder" reactor or basic research on the "fusion" reaction. Decide where you would spend the money, and justify your decision.

Formulating Questions

The way in which you state your questions will often determine its effectiveness. Here are a few points to think about:

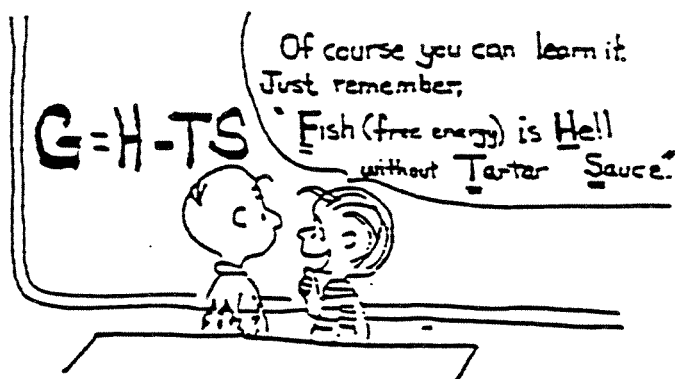
1. **Avoid ambiguous questions.** Ambiguous questions frequently can be avoided by using the corresponding written question as a model. A written exam question is best stated as a directive: name..., write..., balance..., devise a synthetic scheme..., etc. When you ask a question, you will use words such as what, how, and why. When you formulate your oral question, think of the corresponding directive you would give for a written exam question.
2. **Avoid "yes" and "no" questions.** For example, the question "Is carbon monoxide considered a pollutant?" is almost certain to be followed by "Why is carbon monoxide considered a pollutant?" so you might as well begin with the second question.
3. **Avoid double-barreled questions.** Questions which pose two problems simultaneously are confusing and are to be avoided. For example, the question "What is the difference between fission and fusion, and how is electrical power generated from these reactions?" is actually a three-in-one question.

Questioning and Responding Techniques

The manner in which you ask questions and treat responses is as important as anything else involved in questioning. Thus far, we have dealt with the levels of questions, the strategy of selecting questions, and the phrasing of questions. Even though these aspects of questioning are important, the effort you expend on these tasks is lost without follow-through in managing the questions.

1. **Wait-time.** After you ask a question, other than a memory or recall question, wait about three seconds before selecting a respondent. Do this even if someone volunteers immediately. After a student responds, wait about three seconds before you respond to the answer. By waiting after your question, you give everyone in the class an opportunity to think about a response. If you pick a respondent immediately, the other students are under no pressure to think about a response. They may listen to the respondent, or they may pay little attention. By waiting after a response, you give the respondent an opportunity to expand upon his/her answer. Frequently, the student responder will self-initiate an extended response, and thus you won't need to use a probing question to elicit the extended response.

- Distribute Questions.** Distribute questions among students so that many are brought into participation. You should choose from among volunteers, but you should also feel free to call upon students who are not volunteering.
- Reinforce Responses.** You may reinforce responses with verbal praise (good! excellent! etc.) and with nonverbal encouragement (smile, nod). You may also reinforce a student's response by repeating the response. **Never ridicule an answer.** You may be tempted to do this when a student makes a foolish response, one indicating that the student has been inattentive or has not prepared. The problem with such ridicule is that the act of responding is punished along with the response (see the Project TEACH module on Reinforcing Student Behavior -- punishment as a discouragement technique). The student subjected to ridicule is less likely to respond foolishly in the future. However, the entire class feels that their safety in responding to the questions is threatened, and the overall response frequency is lowered.
- Use Your Students.** Use your students to reinforce one another and to help you eliminate erroneous responses. For example, ask the class to comment on respondents' answers both when they are correct and incorrect. This is a good way to allow a student's peers to deal with his/her foolish response.
- Encourage Student Debate.** When you are using divergent questions, it is particularly helpful to get students debating with one another. For example, when two students have each devised synthetic routes to a compound, a debate between the two as to which is a preferred route is going to be a valuable learning experience for them and for the class. Such a debate may be conducted at the evaluation level of the goals hierarchy.



B.1 SOME ADDITIONAL CONSIDERATIONS³

- Try to avoid embarrassing students in front of their peers. If a student seems embarrassed, try not to force him to answer a question; give credit for a partially correct answer; consider answering his questions in

private. [A student who fails to make eye-contact with you is probably unprepared to answer your question.]

2. When a student asks a question, find out how many other students have the same question. If a large number of students have the same question, consider the following:
 - a. Give a review of the background material.
 - b. Assign an exercise to provide practice in answering the question.

If only a few students want the question answered, consider:

- a. Speaking to the student (or group of students) after class.
 - b. Tutoring the student during office hours.
 - c. Providing remedial exercises and help sessions.
3. In answering a student's question, don't tell him more than he wants to know (remember the story about Johnie who asked his mother where he came from).
 4. If the question asked by a student is important for future learning (e.g., a prerequisite), the instructor should answer the question immediately.
 5. If a student's question indicates that he has not learned materials previously covered, consider working with him privately after class.
 6. If a student asks a question the instructor cannot answer:
 - a. Avoid bluffing an answer!
 - b. Tell the student you will look up the answer and tell him next time, *and follow through*.

B.2. SOME PRACTICAL SUGGESTIONS⁴

The following checklist of techniques should help an instructor to decide on the best course of action to take when the class seems troubled by questions.

- Make the decision to wait patiently until the class is silent and thinking. Consider other problems or questions which will be required to finally answer the original question.
- Rephrase the question to make it less confusing. Break it up into parts, if possible.
- Relate the question to student experience.
- Ask the class to pick out the word or words in the question that interfere with understanding.
- Postpone the question in order to provide more background.
- Delay the question in favor of a general review.
- Use a problem-solving approach with the class to indicate that their difficulty is a mutual concern.



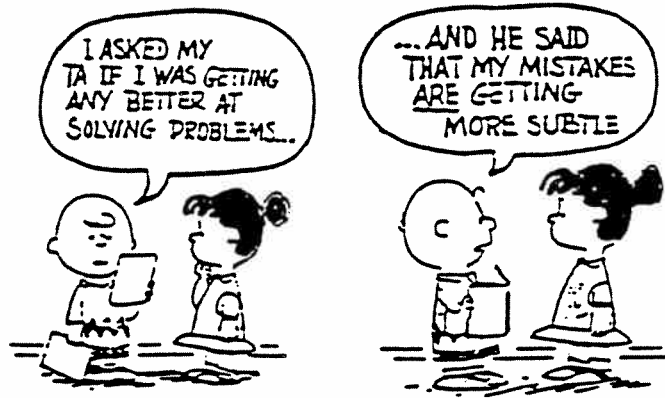
C. TUTORING

The following contains only the summary of "Ways to Tutor" from PROJECT TEACH.

Summary

An effective tutoring model employs several steps. Although the steps are sometimes overlapping, they can be analyzed:

1. **Personal identification.** Build a personal relationship with each student. You really should be helping somebody, and not just anybody.
2. **Student participation.** Encourage student participation; get the student actively working on the problem or concept.
3. **Asking questions.** Stimulate student response through asking questions that lead to solving the problem or illuminating the concept.
4. **Praise, or reinforce.** Employ generous amounts of praise (positive reinforcement) whenever warranted. **Seeking clues to difficulties.** Analyze the student's understanding in terms of principles, concepts, and skills.
6. **Accepting and understanding feelings.** Identify the student's position -- try to remember what it was like when you were a student.
7. **Evaluation of learning.** Encourage the student to demonstrate mastery of the material and provide opportunities for appropriate practice.

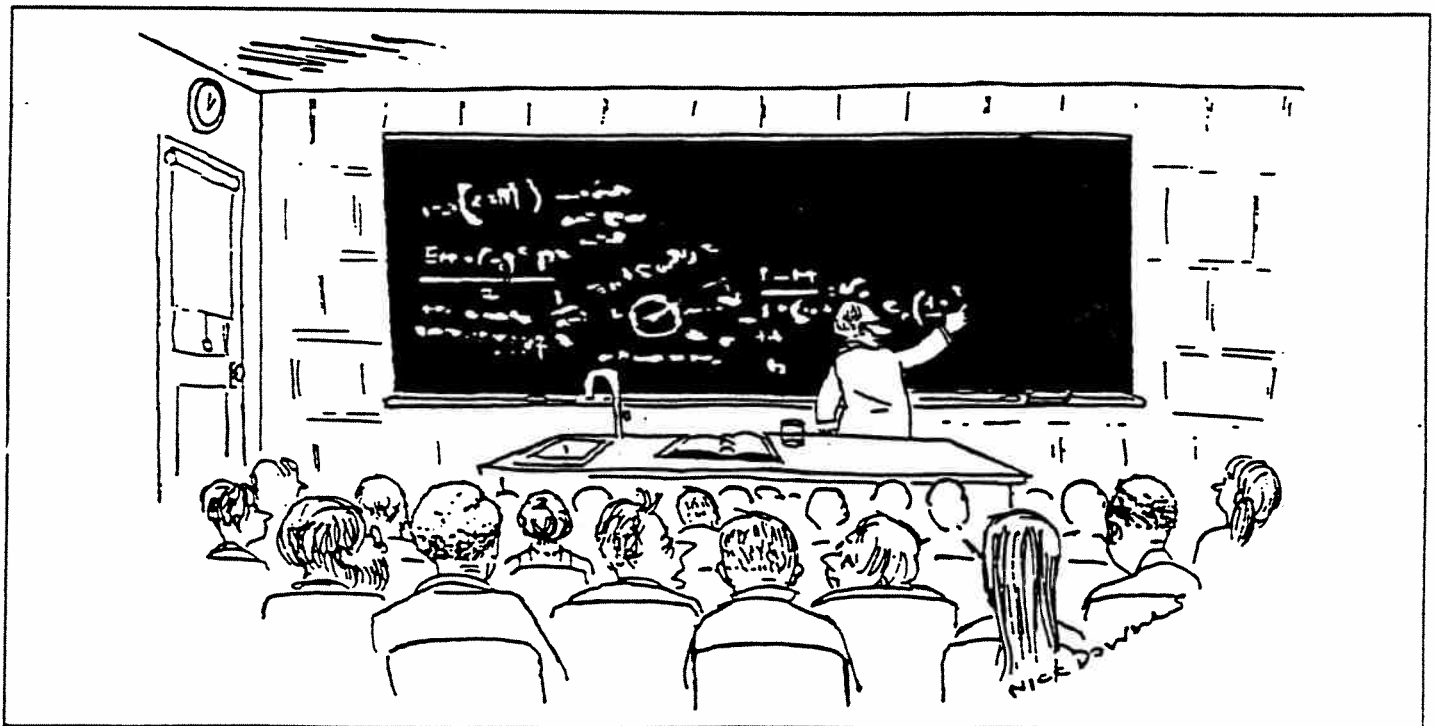


D. BLACKBOARDMANSHIP

If at first thought the simple act of writing with a piece of chalk hardly seems like skill, then perhaps it is because we so seldom stop to look at our blackboard work from our student's point of view. The guiding principle of blackboardmanship is: Look at your writing as though you were a student in your own class. Probably, almost anything you put on the board will be clear to you; the test that you must pass is to make your blackboard presentation clear to a student seeing it for the first time.

Three facts to keep in mind while planning a blackboard presentation are the following:

1. **Students must be able to see and read what you have written.** Illegible or obscured work is valueless.
2. **Students must be given time to copy what you have written.** Most cannot think analytically while they are writing.
3. **Your board work must be organized so that students later will be able to interpret their notes.** You must be organized in your use of board space as well as in your method of presenting material.

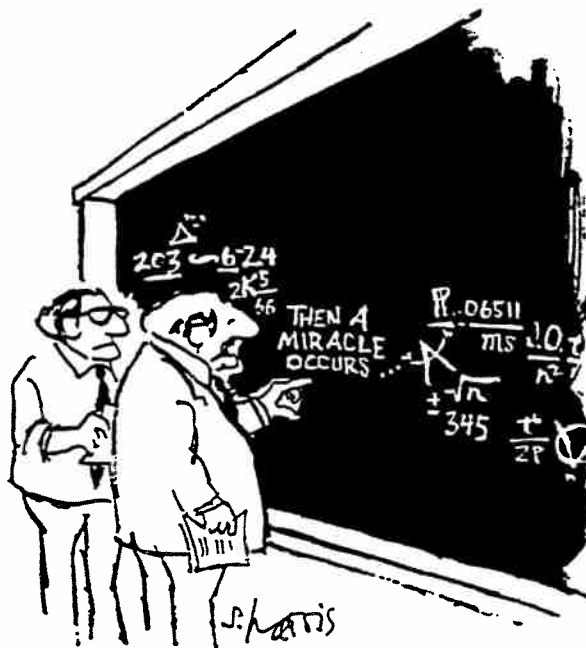


"I think I'm beginning to grasp the concept of infinity."

These points are taken up one at a time in the following discussion.

1. **Seeing and reading.** Even in the average sized room, students in the back rows may have trouble reading words in a small handwriting, and they may not be able to read even very large words if they are scrawled or written too lightly. Unless the floor of the classroom is sloped, students of average height sitting behind the first two rows will not be able to see the bottom of the board. To find the effective bottom of the board, sit in the last row while your class is occupied with some task and note the line below which a student of average height would find it difficult to copy notes. You might want to mark this line with a piece of chalk. If there is a desk at the front of the class, keep it clear of objects (e.g., lecturn, or briefcase) that might obstruct vision.

Try to keep your work visible for as long as possible. If you are right-handed, fill the right-hand panel first, then move to the panel on the left and continue your writing. In this way, you will not be blocking the view of students copying the writing that you have just completed. If you are using a sliding, three-layered blackboard, fill the middle board first, then push it up and pull the front board down. When the front board is full, push it up and use the blackboard.



"I think you should be more explicit here in step two."

2. **Time to copy blackboard.** Most students will copy everything that you write on the board. If you ask them to analyze an idea, they will not begin to think analytically until they have finished copying. When you want them to make a point, stop writing. Let people catch up to you (they may be lagging behind by two or three lines). *Then* begin your discussion. Similarly, if you engaged in a long discussion without writing very much on the board, allow them time to summarize the discussion in their own minds and to write their summary down in their notes before you again begin to use the board or to speak.

Students are sure to be frustrated if the TA modifies part of his board work before the students have a chance to copy it. A physics TA may reach a crucial point in the derivation of an equation and then quickly erase and replace terms. A biology TA may draw a diagram and then rapidly change first one part of the diagram and then another to show a process. A good rule of thumb is: erase only when you have run out of space to write (if you find you've made a mistake, don't go back over the last three panels madly erasing minus signs!).

Then erase only the oldest or least important work, and erase the entire panel to avoid implying a connection between the new work and any unerased work.

If you find that you have made a mistake, explain it, then go back and make corrections, preferably with a different color of chalk. If you are modifying a drawing, use dotted line or some other technique to show changes. Remember that a student cannot make the same erasures that you do without losing his written record of intermediate steps: you can alter parts of a drawing much faster than he can reproduce the whole thing.

3. Organization

- (a) First erase the board completely. This step is especially important in mathematics, where stray lines may be interpreted as symbols.
- (b) If you are to solve a problem or prove a theorem, write a complete statement of the problem or theorem on the board, or write a precise reference.
- (c) Fill in one panel at a time, always starting at the top and moving down.
- (d) Make your notation consistent with that in the textbook or the professor's lecture, so that students do not have to translate from one system of symbols into another.
- (e) Underline, or in some other way, mark, the most important parts of your presentation--the major assumptions, or conclusions, or the intermediate steps that you plan to refer to later on. Colored chalk may help to clarify drawings.
- (f) At best, the blackboard is only a teaching *aid*. It cannot substitute for a logical presentation of the material. Break your presentation into manageable parts and give students a chance to deal with facts and concepts as you present each part, or just afterward. Then verbally outline the next part of your presentation. If you neglect to do this, your students may be copying blindly, without any idea of where you are going.

Evaluating your Blackboardmanship

You can determine your effectiveness at the board in several ways: (a) After class, without prior notice, request one of your "A" and one of your "C" students to lend you their notes. If the notes seem incomplete, ask yourself: "What could I have done to help them catch the points that they missed?" (b) Stop yourself twenty minutes into your presentation and ask yourself, "If I were one of these students, would all of the major points written on the black board be clear and coherent?" If you are not sure of the answer, ask your students...

You will become more effective in using a blackboard as you learn to look at your work from your students' point of view.

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E. ON NOT DOING A STUDENT'S HOMEWORK

Attitudes

Giving in to a student's pleas for "the answer" is detrimental for him/her in the long run. It robs the student of a sense of self-achievement and independence, and teaches him/her dependency and manipulation.

Concern about what the student thinks of you can interfere with what the student needs. That is, preservation of a liberal, do-gooder image is less important than the student learning self-sufficiency.

Goal: Student feeling that he learned a lot and *did it himself*.

Methods

Start Small: Use "success-assured" activities.

Ask the student how he would begin or approach the problem *if he had confidence*.

Ignore the student's actions or statements of anxiety regarding getting the answer. Interrupt negative comments with a question about the problem.

Repeatedly return his attention to the necessary steps he must take.

Ask the student to build on what he *does* know about the question or problem.

Resist answering the question, "Is this right?" Suggest to the student a way to check the answer himself.

Praise the student for small, independent steps.

Yield

1. **The student learns that it's O.K. not to have an instant answer.** He learns this through your acceptance of his pace of doing things. He learns this through your refusal to let anxiety pressure you into giving the right answer. He learns this through watching how you persevere at returning to a step-by-step process. In essence, the learning assistant (tutor) serves as a model of patient perseverance, communicating that the process is more important than the answer.
2. **The student develops greater patience with himself, and lessens his anxiety.** He learns that becoming anxious no longer works as a way of getting his answer. He learns from observing you that you are patient and accepting of his pace.
3. **The student is given the opportunity to experience a sense of achievement and confidence.** He learns this through breaking the problem into small, manageable tasks rather than anxiously hoping for an immediate answer to the whole problem. Other less accepting or less patient people may have never tolerated his pace of solving problems. They may have robbed him of the chance of achieving for himself at his own rate.

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F. SOME PITFALLS TO AVOID

Although it seems psychologically more satisfying to approach teaching positively, it may be effective to list and analyze some negative ways of teaching for emphasis.

This section is a brief summary of Dr. S. Napell's article: "Six Common Non-Facilitating Teaching Behaviors."

1. **Insufficient "Wait-Time"**. After asking a question, allow enough quiet or "wait-time" to allow "all" students to formulate their own answers. Wait three to five seconds before answering the question yourself, asking an additional (but related) question or rewording the original question.
2. **The Rapid Reward**. Again allow quiet-time for responding to a student's answer: "Correct". Make certain that all have heard the answer, repeat it if necessary. You might ask those in the rear, "What do you think about the last comment?"
3. **Programmed Answer**. Don't ask questions which suggest an answer: "How do we go about solving this problem? Should we convert to moles?" "What are some other methods of determining its molecular weight?" "Is this substance volatile?"
4. **Non-Specific Feedback Questions**. Don't ask vague or general questions. Those in most need of help may be so confused that they can't formulate appropriate questions to get help.

Compare the following pairs of questions:

- a. "Who needs help with equilibrium?"
- b. "Equilibrium problems are complex but related. Let's list the various categories of equilibrium problems we covered today."

**

- a. "Should I go over this again?"
- b. "What are some considerations to keep in mind when making up a buffer solution?"

**

- a. "Does everyone understand the answer?"
- b. "Consider what happens to the activation energy when a catalyst is introduced into a reaction vessel. How will the catalyst affect the equilibrium constant?"

5. **The Teacher's Ego-Stroking and Classroom Climate**. Don't belittle or embarrass students. Make an effort to help the students feel "safe" to ask questions.

Avoid starting questions with:

- a. "Obviously, you use the van der Waals equation here to..."
 - b. "Now that I've gone over three rate law problems, you should whiz through this one..."
 - c. "Here's a very simple question about resonance in a conjugated system..."
 - d. "My five-year-old can propose the mechanism to this reaction..."
6. **Fixation at Low-Level of Questioning**. Avoid one word, short phrase or "yes" or "no" questions. These could discourage the brighter students. Ask questions which *stimulate thinking* by allowing students to apply new concepts, etc.

Consider:

Question: Now that we've studied the effects of molecular geometry on various physical properties, what can we say about the comparative melting points, dipole moments, and solubilities in benzene, of octane and pentanoic acid?

G. ALTERNATE METHODS OF TEACHING

This section includes summaries of four teaching techniques described in Dr. S. Napell's article "Six Methods Which Facilitate Learning".

1. The **Lecture** is a time-efficient way of teaching. Although it may not be the most effective method for all students, TAs are often left with no alternative. The following suggestions⁵ may help you prepare good lectures:
 - a. Establish a favorable rapport with the students (exchange a few words with a few within reach, chat about the last lecture, about their thoughts on the course, an item of college interest, etc.).
 - b. Begin instruction with a few questions relating to the last lecture, lab assignment or quiz and tying it in to the present one. 1) Direct these to students in various quarters of the room and enlist the attention of all. 2) Begin slowly, gain in tempo as absorption grows, pay careful attention to the rate they can follow.
 - c. Present the topic in several well-organized blocks rather than one unbroken discourse which causes intermittent lapses of attention and loss of thought continuity; fifteen minutes of continuous exposition is maximum.
 - d. Be sensitive to audience reaction-symptoms: listening posture, rustling of papers, gathering of books, scraping of feet and furniture, etc.
 - e. Conclude the exposition before the end of the period so as to allow time for discussion, questions, and review of salient points. (An explanation at the onset of the course [discussion hour] of the proposed organization and the importance of the summary period is well worth the time spent.)
2. **The Question-and-Answer Method.** (This technique is covered in the first part of this section: Questioning Skills.) Basically, start with simple questions which require that students give informational answers. Gradually progress onto questions which require application of concepts and principles.
3. **The Group Discussion.** If you can apply this method, it's a good way to stimulate student participation. Pose a provocative question, then allow the students to carry on the discussion. The TA should moderate the discussion, clarify materials as needed and eventually summarize the student contribution. After the students have had the necessary background, one could probably get a discussion started with questions⁶ like:
 - a. What would be the global consequences if ice had a higher density than water?
 - b. What would happen to the petroleum industry if work were a State function?
 - c. Suppose that you take two identical clock springs, leave one slack, wind the other tightly and tie it with catgut, and then dissolve each in a beaker of acid. What happens to the work that you exerted to wind the second spring?
4. **Small-Group Problem-Solving.** This method could be used in the laboratory or during TA-drop-in sessions where you might be confronted with a large number of students who have a variety of problems. Group a few students according to the types of problems they wish to solve or lab calculations they wish to understand, and have them solve the problem as a team. Peer-tutoring can be an effective learning tool.

H. TENSION POINTS IN TEACHING

The following is a list of frequently encountered situations in teaching which can become quite uncomfortable. We have listed several possible solutions to each situation. It would be valuable to consider the consequences of each of them (how would you react if you were the student) - some of the consequences may be more desirable than others, nevertheless there are no right answers. You might brainstorm an additional list of alternative solutions.

1. What if you can't answer a question?
 - a. Say you don't know, but will find out.
 - b. Bluff (not good).
 - c. Tell the student to look it up and bring a report to the next class session.
2. What if a student "bad mouths" the course, exam, professor, college, subject matter?

- a. If you agree, go along..."that's been my impression too."
 - b. Defend the system..."there are good reasons why things are done this way.
 - c. Ignore them..."I really can't do anything about it."
3. What if students don't pay attention?
 - a. Admonish them to pay attention..."you'd better pay attention because this might be on the next exam."
 - b. Be cool, ignore them and go on.
 - c. Employ novelty, ask a provocative question..."can any of you give some examples to show how this relates to your world of experience?"
 4. What if you ask a question and there are no volunteered answers?
 - a. Make a joke out of it..."this looks like a 2-point class."
 - b. Ask "What part of this question seems to be slowing you down?"
 - c. Ask a simpler question.
 5. What if nobody does homework?
 - a. Do it for them.
 - b. Have them do it right there in class.
 - c. Dismiss the class.
 6. What if students come in late or leave early?
 - a. Legitimate the behavior - acknowledge that some may have to come late or leave early.
 - b. Keep the door closed so they have to open it.
 - c. Complain or scold them.
 - d. Speak to them privately afterward.
 7. What if the board is not erased?
 - a. Come there early and erase it.
 - b. Erase only the part you use.
 - c. Appoint someone to erase it.
 8. What do you do first in any class?
 - a. Check for questions on previous material.
 - b. Tell a joke.
 - c. Launch into a problem that you thought was difficult.
 9. What if you ask 'any questions' and there are none?
 - a. Dismiss the class.
 - b. Think of another question to ask..."Which was the most difficult homework problem?"..."What part of yesterday's lecture was most incomprehensible?"
 - c. Wait...you can outlast them.

Taken from "Gradman", Dept. of Chemistry, Michigan State University.

Footnotes

1. Taken from Project TEACH: developed with a grant from the Exxon Education Foundation; consists of written materials, videotapes, and an audio tape to be used as supporting media by those faculty supervisors responsible for the training of graduate teaching assistants in college chemistry instruction.
2. Modification of "Principles of Learning and Motivation", Gradman, Dept. of Chemistry, Michigan State University.
3. From "Gradman, Graduate Manual for Orientation," Dept. of Chemistry, Michigan State University.
4. Taken from CDC Booklet, "Questions, Questions, Questions."
5. Justman and Mais, *College Teaching: Its Practice and Its Potential*. Harper & Row.
6. Questions borrowed from Dickerson, Gray and Haight, *Chemical Principles*, [W.A. Freeman].