

第 X 课: How To ... ?

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1 In class

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Some teachers are hostile to questions. That is an **error made by teachers**. Teachers, you will be more comfortable in your job if you try to do it well, and don't think of your students as the enemy. This means listening to your students and encouraging their questions. A teacher who only lectures, and does not encourage questions, might as well be replaced by a book or a movie. To teach effectively, you have to know when your students have understood something and when they haven't; the most efficient way to discover that is to listen to them and to watch their faces. Perhaps you identify with your brightest students, because they are most able to appreciate the beauty of the ideas you are teaching – but the other students have greater need of your help, and they have a right to it.

A variant of teacher hostility is teacher arrogance. In its mildest form, this may simply mean a teacher who, despite being polite and pleasant, is unable to conceive of the idea that he/she could have made an error, even when that error is brought directly to his/her attention. Actually, most of the errors listed below can be made by teachers, not just by students. (However, most teachers are right far more often than their students, so students should exercise great caution when considering whether their teachers could be in error.)

If you're a student with a hostile teacher, then I'm afraid I don't know what advice to give you; transfer to a different section or drop the course altogether if that is feasible. The remarks on communication in the next few paragraphs are for students whose teachers are receptive to questions. For such students, **a common error is that of not asking questions**.

When your teacher says something that you don't understand, don't be shy about asking; that's why you're in class! If you've been listening but not understanding, then your question is not a "stupid question." Moreover, you probably aren't alone in your lack of understanding – there are probably a dozen other students in your classroom who are confused about precisely the same point, and are even more shy and inarticulate than you. Think of yourself

as their spokesperson; you'll be doing them all a favor if you ask your question. You'll also be doing your teacher a favor – your teacher doesn't always know which points have been explained clearly enough and which points have not; your questions provide the feedback that your teacher needs.

If you think your teacher may have made a mistake on the chalkboard, you'd be doing the whole class a favor by asking about it. (To save face, just in case the error is your own, formulate it as a question rather than a statement. For instance, instead of saying “that 5 should be a 7”, you can ask “should that 5 be a 7?”)

And try to ask your question as soon as possible after it comes up. Don't wait until the very end of the example, or until the end of class. As a teacher, I hate it when class has ended and students are leaving the room and some student comes up to me and says “shouldn't that 5 have been a 7?” Then I say “Yes, you're right, but I wish you had asked about it out sooner. Now all your classmates have an error in the notes that they took in class, and they may have trouble deciphering their notes later.”

2 What to do with a problem? [work independently]

When you have a problem, what to do?

- Understand the problem!
 - read the instruction, if any
 - understand the data (i.e., what is given?)
 - understand the objective (i.e., what is the goal?)
 - understand the variables in question
 - observe any connection between data, variables, objectives...?
- verify or calculate some special cases, this will
 - either help you to observe some pattern,
 - or understand better the problem, and feel convinced that the problem makes sense
- Finding a solution:
 - calculate more special cases, do you observe anything special?
 - Do you know a similar problem? Try its solution.
 - Do you know a problem with similar data? Try its solution.
 - Do you know a problem with a similar objective? Try its solution.

If these solutions do not work, can you modify the method a little bit to make it work?

- When you cannot find a solution, what to do?
 - maybe you haven't solved the problem, but maybe you discovered something already, e.g.,:
(1) this and that method seem do not work; (2) the main obstacle is this...; (3) there is one method maybe related, not sure if it works, but you do not really understand that method very well; (4) ...
All these are **partial progress** you've made.
 - stop and take a rest, come back later to try another time
 - do not give up a question because you failed at the first try
- When you come back to a problem for the 2nd (or 3rd, 4th, ...) time, what to do?

Read the lecture notes some more times. Do you really understand the lecture notes. [one good test is this: write down the statement of a theorem in the lecture notes, now do not look at the lecture notes, can you prove the theorem? Talk to a classmate, try explaining the proof to him/her, can you explain clearly? Can you answer your classmate's questions?]

Modify your problem.

- consider a **special case** (such as an extreme case) of your problem, is it easier to solve? If you solved the special case, then consider another special case, but this time it should be special in a different way, can you solve it?
 - simplify the problem: **remove one (or some) condition** of the problem to get a (potentially) simpler problem, can you solve it?
 - **change some conditions** of the problem to get a (different) new problem, can you solve it?
 - without modifying any condition, can you prove a similar but weaker result?
 - what **conjectured lemma** would imply the desired result? Can you prove that lemma?
 - what are the **consequences** of the result? Can you prove the consequences?
- after you solved a problem:
 - do you like your own solution? do you find it ugly or nice ?
 - what was the difficulty (before you find your solution)? and how you overcome this difficulty? now you know this tool can overcome that difficulty.
 - is there any error you've made during solving this problem? what was it? now you know you should avoid such error next time.
 - can you give a different solution? compare your solution to your friends', which one is better? Is your solution really correct? is your friends' solution really correct?

- if some conditions of the problem are changed, what should be the conclusion? and can you solve it?
- further advanced learning:
 - Can you give a different solution to what you've learned from the lecture notes?
 - do you have a better solution for some statements?
 - do you find any errors in the lecture notes?
 - can you deduce some corollaries of what you've learned?
 - do you have any intuition of the results? Can you make sense of the result to you?
 - without the lecture notes, can you teach the content of the lecture notes to your friend?
 - for tools you learned from the lectures, do you know each tool is suitable for what task, the weakness and strength of those tools?
 - create some of your own problems that you find interesting, and try to solve it

3 What to do with a problem? [work collaboratively]

Two amazing values of working collaboratively (e.g., work in a group) are:

- **a problem often magically becomes easier!**

Lots of scientists expressed this feeling that a problem often becomes not that difficult when they discuss it with people. It's hard to express why this happens. But try it yourself. Sooner or later, you will be able to experience this feeling. It is a beautiful feeling you should experience in your college academic life.

- **it's more fun!**

Working independently requires discipline and the capability to focus on problems, especially when you know that your classmates is or may be playing video games or watching videos. But working together is often more fun and do not require that level of strict discipline.

A third value is that by setting a meeting for working together, you are forcing yourself to work on the problem than, e.g. wasting your time on other things. This will make you **more organized and more efficient**.

Some suggestion for working in a group:

- **group size** (number of people in a group): it should be not too large: 2 to 5 is often an appropriate group size;
- **express yourself**: every one is suggested to express his/her own understanding and idea of the problem, and express which part he/she thinks is unclear or what the difficulty is in his/her opinion; etc.

- **listening to others (be open-minded):** others may have a different approach or idea about the problem, you may think their idea seems strange or won't work, but try to be open-minded, do not reject an idea just because you "do not like it" or find it "strange";
- **meeting time:** it's often a good idea to set a specific duration for your group meeting (i.e., 0.5 hour, 1 hour, 1.5 hours, etc). when you meet for discussing problems, focus on discussing problems.

Working in a group is no much different from working independently, you can also follow the suggestions made in Section 2 about what to do with a problem when you do not have a clear solution. You might find that it is also easier to proceed with those suggestions, than working independently.