TEACHING PHILOSOPHY

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On teaching. I have given a lot of thought to teaching over many years as a student and to a lesser extent as a teacher. Teaching is an important and noble profession. Like the question of nature versus nurture the ability of a teacher to contribute to a student's development of knowledge is sometimes debated. I believe teaching has an important impact.

Teaching is inherently difficult and can be improved with practice and attention. In my view it also invigorates the life of a researcher, who is challenged to return to fundamental principles and arrange them axiomatically. It balances the fast-paced research at the frontiers of a field with a more introspective look at its core. I will look for something new each time I teach a course.

On learning. This question is very important both for students and teachers and is the subject of considerable research in itself. Recent studies point out the importance of "active learning" [1]. In "high-tech" classrooms the following technique illustrates the point: The teacher asks the students a question, they discuss it with peers and vote electronically. Majority-misconceptions can be addressed and in general the teacher obtains immediate feedback from everyone.

Active learning may be the latest jargon for what in reality has always been the vehicle for effective education and one does not need a high-tech classroom to implement it. The brain is like a muscle that can be made more powerful with exercise. An essential exercise is to pose questions that encapsulate a particular concept. They should be asked by the teacher and students in the classroom as well as individually. When a student can pose his or her own pedagogical questions, and can explain the answers to peers, she or he is ready to begin learning independently.

There is an obvious difference between a student who is really engaged and one who is passive - in their attitude, even in their level of energy. I believe students can be engaged by attacking a concept from multiple directions. Group work and demonstrations can be a part of this process. Another part of it is moving between principles and applications - between logical framework and problem-solving. Occassionally I will also use an "anecdotal" approach: "James Joule, who hoped to improve his brewery, carefully measured the temperature change in a fluid generated by a paddle wheel and a falling weight. Does this support or challenge the caloric theory of heat as a fluid?" My point here is to convey that processes of discovery are not the linear, succinct, abstract ideas presented in textbooks. Energy was never an obvious concept.

I would also note that knowledge is "re-deployable". Once you have solved a problem, you have unknowingly found the solution to many analogous problems. The conservation of energy in macroscopic systems (thermodynamics) is also invoked to develop a continuum theory for heat transfer. There are many such parallels, even with topics outside of science and engineering.

In the classroom. I recognize that teaching and learning depend on personalities too. Above I note the importance of students confronting and asking questions, but not everyone is willing to voice their opinion in front of a classroom or even within a smaller group. I do not know what the best method is for a teacher to reduce this effect and it depends a little on the particular mix of personalities. I will pay close attention to the effectiveness of my approach.

Perhaps it helps to be aware of the nagging self-doubt shared by even the best of students. It is widespread enough to be dubbed the "impostor phenomenon" [2]. I have confidence in students. The renown and much-loved lectures of Richard Feynman on many subjects provide a good example of how to debunk the notion that "its just too hard". Besides their lucidity these lectures inspire an irrepressible, contagious enthusiasm and confidence.

When a student does ask a question it is crucial to treat it with respect and spend enough time answering it before moving on. This sets the tone in the classroom. I will even return to a question during the next class in order to further clarify it and show that I take it seriously. In fact I intend to continue the dialog on all problems students have given thought to, including exam and homework problems.

Teacher evaluations. I have filled out many teacher evaluations and I tried to be sincere about them. In one instance I was on the receiving end as well. As a graduate student I was very active as TA for the thermodynamics course - so much so that I was asked to teach that course in the following semester [3]. I was fortunate to have had this experience. It was difficult and time-consuming (in spite of which my research prospered). At the end of the course I got mixed reviews in the evaluations: The strongest compliments, which were also given verbally, concerned my lecture style and material while the strongest criticisms concerned grading and difficulty level. I learned a lot from students' comments. I do believe that the diploma granted by the university should mean something, particularly in the core subjects like thermodynamics. Several students in the class felt considerable pride in meeting the challenge and learning about a difficult subject.

Group work and demonstrations. I still recall the one demonstration that was used in my undergraduate chemical thermodynamics class. It was a very simple experiment illustrating the change in molar volume of mixtures and required only a pair of graduated cylinders, water and alcohol. This experiment worked because it reinforces and draws additional attention and thought to a key concept.

Besides "wet experiments" I am also interested in using computer educational tools such as Etomica [4], a hands-on molecular simulation program that runs in a browser. This facilitates what recent textbooks advocate: building an appreciation for the link between macroscopic and statistical/microscopic thermodynamics. I have always been interested in computer aided tools; as an undergraduate I helped develop one of the first online courses and an interactive CD.

As for group projects, this depends on the course. A project using Etomica could be assigned for example, or the steam-tables could be used as experimental data to validate equations of state. I will seek advice on effective organization of groups from professors who have tried them. I believe projects like those in Unit Operations activate minds differently and are a formative experience for many students. They also introduce team-building concepts highly sought after by industry.

One interesting idea is the concept of "vertical groups" [5]. These groups would integrate members from several graduation classes, providing opportunities for mentoring, perspective, foresight and post-graduate networking. This has been implemented essentially in the annual Chem-E-Car competition at AIChE. I think this has been a success. One of the things it does well is to build enthusiasm for chemical engineering as a cutting-edge and fun field.

References

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