

Prof. Key was the winner of the 2003 CAP's Medal for Excellence in Teaching Undergraduate Physics. This paper represents the talk he would have given at the 2003 CAP Congress.

A COURSE ON COMMUNICATION FOR PHYSICISTS

by Tony Key

The demands of a scientific education often mean that graduate students in Physics have poorly developed written or oral communication skills. Some students write well but speak poorly, and vice versa; some are too anxious to gracefully address an audience of more than one, others do not know how to organize their written work. Too often a supervisor's time is spent correcting the language of a graduate report or thesis. Yet it is only over the last decade or so that events have conspired to make the scientific community keenly aware of the necessity of addressing these problems. The use of graduate students as Teaching Assistants, demands better undergraduate teaching. The great influx of overseas graduate students, the requirement of university appointment committees for evidence of excellence in teaching, the ignorance of the general population about scientific affairs, and the politicization of science, have all played a part.

The timing seemed to be auspicious for a course on communication within the Physics Department, and my proposal for a pass/fail one-term credit course for graduate students, was accepted three years ago. I have taught "Effective Communication for Physicists" ^[1] ever since.

In what follows, I will give a brief description of the planning and execution of the course, and some suggestions for any departments that are considering similar initiatives.

PHILOSOPHY

A course on good communication must surely serve as a good model of its subject matter. Accordingly, I feel more than usual pressure to ensure that the course is well taught and that I am a good exemplar. I attempt to make my teaching methods transparent to my students, so that they understand what I am doing and why.

The concept of good contact has been central to my own teaching practice. I attempt to ensure strong and inclusive eye and voice contact, and make my course objectives and instructions to the class clear and unambiguous. I inform students how they should address me, and attempt to know and use student names whenever possible. I provide frequent opportunities for bi-directional summary, review, and evaluation. Feedback from the teacher should be prompt and even-handed, and student input should be encouraged

("A pat on the back is but a few vertebrae removed from a kick in the pants but it is miles ahead in results" ^[2]). Time keeping should be scrupulous, with classes beginning and ending on time; yet flexible planning must leave time for discussion of spontaneous issues as they arise.

The demands of a scientific education often mean that graduate students in Physics have poorly developed written or oral communication skills. The scientific community is now keenly aware of the necessity of addressing these problems.

"The only thing to do with good advice is pass it on. It is never any use to oneself." ^[3] Certainly all of my teaching experience and the results of much research indicate that important learning takes place only when the student becomes fully engaged with the material. Time spent lecturing students on how to communicate is time wasted. Practice, practice, and more practice is essential.

"To communicate" is a transitive verb; although I am more interested in the process of communication than the content, I also want to ensure that the material communicated is relevant to the interests of the students. Also, in

spite of the caveat of the last paragraph, some simple advice can be valuable. I solve the tension between these dual aims by involving students in the choice of topics, soliciting their suggestions, and using interactive group methods at every opportunity.

One of my earliest tasks is to establish a cohesive and supportive group atmosphere where students feel interested, involved, and eager to participate in discussions.

PRACTICE

The possibilities for topics, exercises, games, and mini-presentations are limitless: the following representative list describes some of those I use to put my philosophy into practice. Most are accompanied by appropriate handouts.

The First Class

The first class, as always, sets the tone for the course ^[4]. I expound on my philosophy, explain the minimum attendance and assignments required for a pass (see below), set up the course structure and begin to get to know my students and to let them know me.

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The Name Game

"Remember that a person's name is to that person the sweetest and most important sound in any language." [5] The ability to address one's students by name is generally agreed to be very important. (Beware people who plead that they cannot remember names; our heads are already crammed with all sorts of memorized information. Problems arise, I suspect, from lack of attention caused by distraction, anxiety, etc.) One of the games I play in the first class is as follows. I gather the class in a circle so that everyone can see everyone else (this is a preferred arrangement for all class discussions). I introduce myself: name, education, research field, and one personal piece of information. I then ask the person to my left to repeat this information, and then to introduce themselves using the same headings. The next person repeats my introduction, then that of my neighbour, then gives his or her own introduction. The introductions pass round the circle, with each person first repeating those of the two preceding. The necessity of paying attention and the repetition makes this an almost fool-proof method for a class of around twenty or less.

Minutes

Every class I ask for 'volunteers' to take minutes and read them out at the start of the next class. It is often useful to build class camaraderie by having this done in pairs or small groups depending on the size of the class and the number of meetings. This activity provides each student with another opportunity to write and to give a brief presentation in class. It also serves as a useful reminder of what we did, and a summary for anyone who may have missed the previous class.

Feedback

"O wad some pow'r the giftie gie us/To see oursels as others see us/It wad frae monie a blunder free us/An' foolish notion" [6]. The giving and receiving of feedback is an essential follow up of the in-class presentations and micro-teaching (see below). Early in the course, I give a short presentation on how to give constructive criticism and feedback. At the start of each class I hand out small pieces of paper to each student on which they record their comments about the class; these are collected by two volunteers at the end of the class who present an oral summary following the Minutes at the start of the next class.

Jokes

At the start of each class I ask for two 'volunteers' to tell a joke. This gives each person a brief chance to address the class, to wrestle with a spontaneous presentation, and provides a light-hearted start to each class.

The Teaching Dossier

Increasingly, applicants for academic positions are asked to present a Teaching Dossier that details their teaching experience and contributions. I give a short lecture that suggests information to include and a possible organization for the Dossier; I encourage students to start one. [7]

Physics Education Research

For an early assignment, I select half a dozen seminal papers from this field. [8] Depending on the size of the class, I organize groups of two, three, or four, each member of which reads the same paper. Each group then gives a joint 20-minute presentation of the main points at the next class. In this way, everyone gets an opportunity to give a presentation in a supportive group, and the rest of the class learns about the paper.

Learning Styles

Although this is a course about practice rather than theory, I want to let students know that their way of learning is not necessarily that of their students. I present a few of the well-known classifications of learning styles to emphasize this point. I use in-class questionnaires to make the information personal to each student.

Lecturing

Using small group interactive methods to access students' own experience, I introduce Murray's excellent research on the behaviours of university lecturers [9]. I also hand out the paper of Brouwer *et al.* [10] for students to study after class. Students are then asked to attend one of my colleagues' lectures before the next class (my colleagues have been very willing to invite this attention), and to provide critiques that are used as the topic for a class discussion in the following week.

Elements of Form [11]

Five or six at a time, students line up in front of the class to make the following speech - "Good afternoon, my name is ___ and I am a member of the ___ research group". Once all class members have given the address, the same talk is repeated with a wide variety of stylistic variations for each repetition; high and low voice volume, high and low tone, with and without gestures, various body postures, with and without eye contact, etc. This exercise, while energizing and fun, focuses attention on the importance of the process of delivery as opposed to the content. Audience feedback provides information on the effects of different modes of address.

Rhetoric

Each student memorizes a favourite piece of literature and declaims it in class. Selections have varied from Churchill's wartime speeches through Korean and English poetry to passages from a Spanish novel.

Use of Transparencies

In physics, the use of transparencies is still widespread; indeed, I use them for almost all of my presentations in the course. Rules for effective use are simple, yet worth passing on. [12]

Posters

Students' first presentations at conferences are often in poster form, describing their research. Since they have had much more experience of this form than I, students who have already prepared a poster bring them to class along

with tips for preparation. A lively discussion often ensues.

My Word

This exercise, based on the BBC word game of the same name, encourages students to think on their feet, and helps reduce anxiety. Groups of four, five, or six are formed. The first volunteer in each group is required to speak for a full minute on a topic chosen by the moderator. Pauses, repetitions, or fillers ('um', 'ah') are subject to a challenge by any group member. If accepted by the moderator, the challenger takes over the same topic for the remaining time, with the same restrictions. Points are awarded for successful interruptions or completion of the minute. In class, I allow students to choose their own topic from a list of simple Physics topics, and the validity of interruptions is determined by group vote.

Awareness

A good speaker is very self-aware. Using a variety of experiential exercises and by constant reminders, I encourage students to pay attention to how they speak, how they breathe, how they stand, to whom they address their words, and how much attention they pay to their audience. These exercises, useful in themselves, allow students to attend to how they use their primary supports - breathing and legs. Most importantly, attention to here-and-now awareness reduces performance anxiety.

Gender Issues

Much attention has focused on the impact of gender differences on academic performance in physics and retention rates. I think it important to inform my students of the issues involved and encourage them to ensure that their communication is inclusive. Fortunately, one of my graduate students^[13] is an expert in these matters and I prevail on her whenever possible to summarize the research, using questionnaires and class discussion.

Job Application and Interview

Towards the end of the course I invite students to submit a letter of application and a resumé for a position that might interest them. At the following class, I invite a couple of colleagues - preferably one from the university and one from the private sector - to join me in a mock interview of some volunteers.

Scholarship Applications

All students have to apply for scholarships. The preparation of an application is an excellent opportunity for students to summarize their research intentions and to prepare a brief and persuasive resumé. I invite our Associate Chair to give a presentation on grant and scholarship applications^[14], and give a mock application as a homework assignment.

English Usage

The use of words and subtle points of grammar often confuse even native English speakers. I prepare a list of about 50 sentences that contain poor grammar or the misuse of

words. The list can be given as homework, or, better, processed in small groups in class. Good sources for such sentences are the classic and delightful book by Strunk and White^[15] along with several others^[16]. I also prepare a handout on Scientific Writing based on these texts (see the section on Written Homework Assignments below). I base one homework assignment on an excellent interactive Web site that teaches simple grammatical usage^[17].

Written Homework Assignments

This is a central part of the course. Each week I hand out an assignment that requires a 600-word essay or report. I read each carefully and comment copiously. This task is easiest for word-processed documents that allow me to give feedback within 24 hours. I discuss issues of general difficulty of grammar and style in the following class. The challenge is to find topics of interest to students from diverse areas of physics, and ones that would be useful in later life. I include a variety of document styles - a formal letter, a business letter, an in-house report, a newspaper article, a scientific essay, a job or scholarship application. I emphasize organization, clarity, and brevity. A handout on scientific writing clarifies the differences between it and creative writing such as poetry or fiction.

Micro-Teaching

This is an essential part of the course, held outside of class time in small groups of three or four students. In turn, each student gives a 10-minute presentation on a topic of their choice. Necessary aids are provided. Each presentation is video-taped and immediately replayed. After the speakers' comments on their own performance, the audience gives oral and written feedback. At a later session, students repeat their presentation, prefaced by a brief statement of which areas they have worked on to improve. The video tape of this session is made available for home study.

ORGANIZATION

The class runs for 13 weeks of the Spring term, one two-hour session every week. I make sure that the class room has moveable chairs for small group work and good projection capabilities. I recommend that students buy at least one book on writing, with Strunk and White^[15] highly recommended. I also suggest the purchase of one book on communication or teaching, with McKeachie^[18] a strong favourite.

Since these students are volunteers rather than prisoners, their motivation is high. My responsibility is to support this motivation with clear but reasonable expectations. To gain a Pass grade, students must attend at least 10 classes, and must hand in a written assignment each week. In addition, they are expected to 'volunteer' at least once for Minutes, Feedback, and a Joke. Finally they must attend up to four hours of the Micro Teaching sessions. All students have so far exceeded the required minima.

CONCLUDING REMARKS

Although I have given countless two- or three-hour workshops on teaching methods, containing material that over-

laps with this course, they do not in any way meet the need for a prolonged and systematic approach to good communication. Communication needs continual practice, with ongoing feedback over a reasonable period. While most students - and supervisors - will admit that the topic is important, it is unlikely to reach many students unless some academic credit is given. The Pass/Fail classification allows individual students to progress at their own rate, and initial incompetence need not be a handicap. Researchers also need to be convinced that courses that teach skills have also a place in a rounded graduate programme.

Students are especially appreciative of the micro-teaching sessions. The weekly written assignments are essential. Absolved of the requirement of awarding marks, I can tailor my comments to each individual contribution. Occasionally I invite the re-submission of an assignment that has extensive problems. The variety of backgrounds and competencies stretches my own abilities to the limit. Oral presentations also vary widely. Some students are expert in Power Point; others use handwritten transparencies. Although we discuss the benefits and drawbacks of each style, I do not insist on any one.

Student response to the course has been enthusiastic, and the enrolments, not surprisingly, have been among the largest of all the departmental graduate physics courses. To date, approximately 40 students representing most of the subfields of physics have taken the course over these three years. The course evaluations have been excellent, with students rating the course workload as average compared to other graduate courses. All students responded in the affirmative to the question 'Knowing what you know now, would you have taken this course'.

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11. This exercise was developed by Professors Doug Reeves and Grant Allen of the Department of Chemical Engineering and Applied Chemistry, University of Toronto; both have been most generous in allowing me to adapt their work for use in my class.
12. Of the many Web sites containing such information, I found the one at <http://madvax.maths.uwa.edu.au/~alice/scicom/slide-use.html> to be particularly useful.
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