Summary of Teaching Experience and Philosophy

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I have complemented my work in research with an active participation in teaching that has exposed me to students of various levels in different environments. My goal in teaching is to incite the feeling of discovery, thus inducing independent thinking and interest in physics. Research can, indeed, play a strong role in the learning experience.

At the University of Washington, I have delivered introductory physics lectures as a substitute instructor, following the usual lecture–with–demonstration format presented to a large (~ 100 students) class. The challenge of effectively fomenting student participation in the classroom motivated me to engage in the novel tutorial program designed by L.C. McDermott's physics education group, intended to induce students to ask themselves the types of questions that lead to the development of key physical concepts and scientific–reasoning skills. Weekly activities consisted both of training on the tutorial material and common student misconceptions, and of the actual tutoring of students, who worked in groups of four or five on a set of hands–on instructional modules. This has given me the opportunity to explore new ideas in teaching in a very satisfactory setting, where the strong interaction with students allows the tutor to motivate, understand difficulties, and observe progress in even the less–prepared students. It has also made clear some of the obstacles that are faced in doing so, in this case the limited scope of material covered. Later at Caltech I have used some of this experience in teaching part of the introductory course for non–physics majors, consisting mainly of recitation sessions in a class of about 15 students. In the Spring 2001 I am teaching an honors course at the University of Arizona. In addition to this exposure to undergraduate students, I have taught graduate–level courses at summer schools. *HUGS at CEBAF* was a particularly positive event as it involved contact, over several days, with about 20 students from many national and international graduate programs in nuclear physics. I have also interacted with individual students in research–oriented training: two students have taken semester–long courses with me at UW, and a student has started a thesis project at Caltech under my supervision. I have also extensive experience with presentation of departmental colloquia and seminars, and of conference talks.

Reflecting my experiences not only as teacher but also as student, I view learning as an active process that takes place more within the student than in the classroom. It is a process that mirrors discovery in research, and I find that most students show vigorous interest in learning when they experience the process in this way. I consider the role of the teacher and teaching methods in accordance to this philosophy, their very important role being to motivate, trigger, assist, and speed–up the process.

This point of view guides my attitude as a teacher. The interaction with students is basically designed to transmit a passion for discovery, through discovery in physics. I find non–physics undergraduate students mostly unaware of the relevance of physics to an understanding of the world. My teaching at this level then relies continuously on attempts to draw the student's interest into physics by relating it to everyday experience. This is accomplished by emphasis not on abstract examples, but on real–life or science–fiction (such as the television show *Star Trek*) "phenomena". Mathematics and abstraction, being integral parts of the scientific reasoning, are not watered down, but are introduced slowly, always in a physics context. Physics students are kept interested by the inclusion of advanced topics interspaced with the standard material.

For example, in a course on quantum mechanics, it requires little more than exposure to the one–dimensional square well, to the harmonic oscillator, and to spin, to allow the instructor to introduce ideas such as scale invariance, renormalization, and supersymmetry. The point is not so much to teach such specific topics as it is to modernize course content without requiring drastic curriculum revision. A course that gives the student a taste of truly modern ideas is the best way to make him/her part of an exciting enterprise.

Teaching methods have to be conducive to an active student role, not a substitute for discovery through reasoning and problem solving by oneself or in group. In class, I promote student participation with small assignments, such as letting them derive the next step in an argument or perform primitive experiments. The traditional laboratory, because it does mimic an actual experimental discovery processes, is still a valuable tool. However, I would like to explore other methods of teaching that could help bridge the common gap between lectures and laboratory, so students can more easily move back and forth between measurement and modeling. A low–tech approach could be a limited tutorial activity mixed with traditional problem solving. This could for example take the form of directed study in groups of simple problems that can be treated both qualitatively in hands–on activities and mathematically as in textbooks (for example, study of a top or tip–top in a mechanics course). Given resources, I would employ computer–assisted and web–based techniques; specifically, basic–physics visualization and more advanced algebraic–manipulation programs, as these techniques might mitigate some of the mathematical problems that distract students from physics.

Most importantly, I would like to involve interested students as much as possible directly in my own research. Frontier questions in nuclear physics can often be addressed by simpler quantum-mechanical problems accessible to upper–division undergraduates, and almost always broken into enjoyable little pieces to which even beginning undergraduates can contribute. In either case, these research problems can be quite an effective tool for the development of a quantitative attitude in the solution of complex problems. Research also forms the ideal context for a step in computer education beyond the common classroom activity where the student mostly consumes prepared packages. Computing can be made a professional strength through the motivated use of *Mathematica* to visualize and symbolically solve equations, and to facilitate the learning of a high–level language like C, then employed in the writing of numerically more intensive programs. In other words, besides the growth of student self–confidence that comes with any research, theoretical research in particular provides important professional skills.

One example is recent work that I carried out with two undergraduates in the UW REU Program. In the resulting paper ("Singular Potentials and Limit Cycles", submitted to *Phys. Rev. A*), we studied —using both analytical and numerical *Mathematica* tools— the low–energy behavior of scattering in a singular potential. This is an example of renormalization in a quantum–mechanical context, and we found limit–cycle behavior previously unknown in simple systems. Many other aspects of my research (such as scattering on few–nucleon systems and thermal nuclear matter on a lattice) serve to illustrate the application of classroom concepts (such as spin and wavefunction average) and numerical methods (such as Monte–Carlo algorithms).

I strongly believe that integrating research and teaching remains the cornerstone of higher education.[1]

[1] See, for a recent example, the description by J.W. Norbury and G.R. Sudhakaran in *Forum on Education of the American Physical Society, Fall 1998* of how research experience was one of the major factors in the revitalization of an undergraduate physics program.