TEACHING UNIVERSITY ASTRONOMY IN A MEGALOPOLIS: THE "ASTROTINO" APPROACH

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1. Observing the Students, the Textbooks, and the Skies

About every other undergraduate student eventually takes the UCLA elementary astronomy class *Astronomy 3*, and the two of us have been teaching about 1,000 of them every year. We will not repeat complaints about their poor and patchy high-school preparation in science, but we must mention it as an important phenomenon in U.S. education. The European system appears to be preferable, in which mathematics, chemistry, physics, and biology are mandatory and taught every year, although only 3 hours per week. It prevents large memory gaps and the spiral-wise parallel development in all four subjects makes it possible to teach on a higher level every subsequent year.

In our astronomy teaching, we attempt both (1) to explain the structure and evolution of the universe by systematically using fundamental physical concepts (related, if possible, to analogous terrestrial phenomena), and (2) to encourage the students to observe the sky and watch the phenomena. In order to realize this plan in just 10 weeks, we avoid voluminous textbooks, in particular those that devote too much space to the solar system. Regrettably, this has recently been a dominating trend. Another unfortunate tendency in the textbook business is to suppress actual color photographs of important objects, and to replace them by X-ray pictures in false colors. Thus, in an entire textbook, there may not be one direct optical picture of a planetary nebula or bright spiral galaxy. We are afraid that this trend will spread into popular magazines and calendars, and that in the next *Swimsuit* issue we will see only false-color maps of skin-surface temperature distribution for pretty girls, or perhaps X-ray images of their kidneys.

We also encourage students not only to observe the sky with our telescope on regular Open Nights, but also to watch the stars without a telescope, recognize the constellations, and follow the motions of the moon and planets. The limiting magnitude is seldom better than 3 from the UCLA campus, but we have many clear and reasonably warm nights on which the main constellations and bright planets can be seen even from the campus. And we rely on the students' interest in back-country trips. However, only about 15 per cent of the students listen to our exhortations; it seems to us that inertia plays a significant role.

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2. ASTROTINO

Our Way of Emulating and Explaining the Phenomena

Astronomy not only enables but also badly needs visual demonstrations, and today it is possible to go beyond slides (which are beautiful but static), and beyond films (of which few are available and some are becoming rather obsolete; and which are frequently cumbersome as teaching aids). Many of the great strides in our knowledge of the Universe have not yet been adequately covered by films.

We are attempting to strike a middle road between static slide displays and immutable film strips, and are developing a project called ASTROTINO (Astronomy Teaching Innovation), which utilizes multi-color, very high resolution *interactive* computer graphics. The visual programs are generated by a MicroVAX or Sun-class computer graphics workstation, and then displayed on a large wall-screen directly as an integral part of the lecture presentation. Our system is capable of animation of images and graphics that simultaneously display up to 1024 different colors.

The instructor runs a program on a terminal in the classroom which tells the MicroVAX to select previously stored images (or sequences of images) or to run a code that generates in real-time one of many available displays. Previously established parameters or interactively-selected set-ups can be used to vary the demonstration. Thus, when a student asks about a specific item, the program can be re-entered at the critical spot; and if it is necessary to show how the initial parameters affect the outcome, a new run can be started.

We have developed a library of graphics functions, all written in FORTRAN, that are used to produce the plots and animation sequences. New display packages are continuously being developed in this framework.

Among the demonstrations currently available are: The appearance of the night sky at any chosen time or place, including daily motion animation with user-selected time-steps; the phases of the moon (an extremely confusing topic for city students!); a realistic emulation of twinkling; an extensive demonstration of the emission and absorption line spectra of a variety of common elements; a very popular animation of the excitation and subsequent de-excitation of an electron via the processes of absorption and emission; an observational H-R diagram; an animation that allows the students to watch a star move across the H-R diagram and change size in time steps that are proportional to actual evolutionary time scales; depiction of constellations and their secular changes in shape due to proper motion; animations illustrating the geocentric and annual parallax; an orrery and an animated solar system model that explains retrograde motion and the most important aspects of planetary configurations; and Roche models of selected interacting binary systems with animated trajectories of gas streams.

Discussion

D. Hurst: *You make extensive use of visual aids in your course. Do you include* *exam questions that cover these visual aids (*e.g.*, identifying a type of object from a slide)?*

C.D. Keyes: Yes, we occasionally do show slides, asking the students to recognize the object, its type, its role in the universe, *etc.* It can be done on the multiple choice system, even in large classes, but it does require special preparations (starting the slide show at the beginning of the exam; having different questions on different versions of the test to prevent cheating.)

THE PAPERLESS ASTRONOMY CLASSROOM

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The "Paperless Astronomy Classroom" was instituted at Edinboro University of Pennsylvania in the fall semester of the 1985–1986 academic year.

The goal of this endeavor was to teach an elementary and some advanced astronomy courses "on line" with the use of multiple terminals supported by a Digital VAX 11/785. Currently the system used is a clustered VAX system using two VAX 11/785's and one VAX 8550.

The procedure of the "paperless classroom" eliminates the need for the transfer of paper between professor and students (homework, exams, supplementary handouts) in the first phase and eliminates the need for a textbook in the second phase.

An equally important goal is to provide additional enhancement for the student that may not be convenient or easily available from a textbook and the traditional classroom. Such an enhancement is series of large data bases, some of which can be the small data bases that traditionally appear in the appendices of textbooks. Another example might be a data base of graphs and charts (*e.g.*, H-R diagrams, periodic table, abundance tables and graphs, binding energy curves, *etc.*).

The advantages to such an approach are many: The system

- is less expensive for the student.
- is less expensive for the college or university (paper costs).
- gives students access to enormous data bases.
- allows students to take instant tutoring lessons on a chapter-by-chapter basis or on a topical or subject basis.
- gives students access to powerful calculation capabilities.
- allows the student to interact on-line by changing parameters of a calculation and seeing the instantaneous changes in the results, *e.g.*, change the sum of

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