ASTRONOMY IN ALICE'S RESTAURANT

By Richard Dietz

It is one thing to propose a radically different approach to education and quite another thing to put that approach into practice. Richard Dietz does both in his astronomy teaching at the University of Northern Colorado. In this special two-part education feature Dietz describes his philosophy, his methods, and his students' reactions, all of which can give you a valuable new perspective on your own teaching.

Richard Dietz is currently an associate professor at the University of Northern Colorado. For the past several years he has devoted his time to climbing mountains and helping people learn things about astronomy. He finds the university life in Greeley satisfying and confesses to suffer “from the professionally dysfunctional disease of being interested in everything.” A passion for mountains has taken him from Alaska to Peru and many places in between. He did his undergraduate studies at Caltech and received his Ph.D. in astro-geophysics at the University of Colorado. He was with the Institute for Astronomy of the University of Hawaii for four years.

The cartoons in this article were drawn by John A. Eddy who also received a Ph.D. in astro-geophysics from the University of Colorado. He is currently working at the High Altitude Observatory, National Center for Atmospheric Research in Boulder.
"Nothing but responsibility for their own lives makes people grow up and get competent."—T. Roszak

For the past five years I have been employed to teach astronomy at the University of Northern Colorado. It is just possible that in that time I have taught something to somebody, but what I value most is the education I received in the ways of spending time with students to our mutual benefit. I was once a traditional teacher with lectures and reading and tests, but today those concepts are so foreign as to be unrealistic. In this article I will describe my present philosophy regarding education.

WHY STUDY ASTRONOMY?

In this decade education is being demythologized. The process has by no means been completed, but a good start has been made. I went through the educational machine at a time when the Ph.D. was considered the holy grail. As effect follows cause, the attainment of that goal would lead to one's name on the cover of The Astrophysical Journal and other comparable delights. Today no such guarantee exists. A degree of any kind admits one to compete in a certain job market and little else. This truth has now become clear to both the doctoral student in astrophysics and the B.A. candidate in sociology. Thus the economic incentive to toil for a degree is vanishing, just as the use of the University as a shelter against the draft vanished a few years ago.

Concurrent with the new economic picture, came a realization that education as a panacea for the nation's ills was not effectual—see C. Jencks (Inequality). These changes in society require a new look at the question—Why Education? What is the function and purpose of education today—in particular education in astronomy? To begin with, I assert that to be a valuable member of society one needs to know absolutely nothing about astronomy. This may be difficult for many to accept, but I feel it is self-evident.

For almost all students, then, the answer to why study astronomy must be for the joy of knowing, the thrill of discovery and the pride in being able to do something well. Lest anyone think that I single out astronomy for its utter lack of utility, I submit that there is no evidence to indicate that a random human being is better off for knowing any science at all. Learning Newton's Laws is not an ennobling experience that any person is better off for. Those laws will not help him cope with the problems of war, racism, poverty, etc. which beset our civilization. How many universities try to teach their students how not to hate and how to live in peace with their fellow man? If they did then education would have prima facie survival value for our civilization. It is not obvious that it serves such a role now.

THE MATTER OF VALUES

I have mentioned topics not normally found in astronomy journals. This is because I look at astronomy, science, and education in that context and that may account for some of the conclusions I have reached. Let me expand on this point by looking at the matter of values. I see frequent examples of the things many teachers value of their students. The list includes the ability to follow directions, the ability to come up with the correct answer, the inclination to work diligently. Are these characteristics that would be valued highly in anyone but a student? Do we look for them in a next-door neighbor, in a spouse, in a mayor? I doubt it. I would have us approach education with the intent of valuing students for the same reasons we value folks who are just human beings. I value them for their ability to love, their desire to experience the joy of life and their uniqueness. As with other educators my greatest hope is that my students will grow in those aspects I value most.

PERFORMANCE VS. GROWTH

It is possible to view the educational process in terms of McCluhan's medium-message concept. If the medium is a class-room situation in which memorization, carefully prescribed writing exercises, and cookbook laboratory exercises occupy the central position; I see the message as "Learn how to follow orders." There are other possible messages to send like "I care about you" and "I want to help you grow." Is it lack of practice that makes those messages so hard to send? Is it years of conditioning that makes them so difficult to accept when received? By the time students reach college they have learned how to follow instructions very well—they have been carefully selected for that ability in years of public school education. My impression is that in most cases this has been accomplished at the price of stifled creativity and an undeveloped capacity to experience the joy of learning. The process of education has become for them purely mechanical; the accumulation of credits toward a degree they may not know why they are pursuing. Somehow in the daily stream of assignments and tests students are unable to find time to consider the questions of who they are and what life is about. Another way of considering this dichotomy is to contrast education as the acquiring of skills with education as a mechanism to promote change. I am not opposed to the acquisition of skills. In fact, I encourage students to learn how to do new things. However, an education perceived solely in those terms is a shallow one—a sterile, soulless experience. Most teachers face this choice and opt for what they feel comfortable with—the way they were taught. They, after all, acquired sufficient skills to advance to their present position, so there must be something good about that approach. It is here, I believe, that the improvement of science education must be attacked. The shifting of emphasis from performance to growth can be the most significant
advance in education in this century. It is said that students must be confronted with reality—be it the reality of our economic system or the reality of the physical world around us.

Some words sound warning bells in my head and “reality” is one of them. In such situations it is well to inquire as to whose reality is being discussed. My experience leads me to believe that reality does not exist apart from a value system. Most people probably conceive of a physical reality based upon values compatible with cognitive rationality, the mode of knowing accepted by scientific disciplines. Writers such as T. Roszak have recently considered the limitations of this narrow view of the universe so I will not dwell upon them. I would like to make clear with an illustration the validity of alternative perceptions of reality. Consider from the standpoint of the student the reality of the two planets: Pluto and Tralfamadore. One discovered on photographic plates after an exhaustive search by Tombaugh, the other generated by the fertile mind of Kurt Vonnegut. Which can be said to have the greater degree of reality? They both can be read about in books held in high esteem by educated people. New information about both is conveyed by a technique I can only describe as revelation since neither can be seen in most telescopes. Ph.D. theses have probably dealt with both of them, and who is to say astronomy is a more realistic endeavor than English. If you say that only one of them is really real, you are just making a statement about what you consider to be admissible tests for reality. Without arguing further the question of reality I could say that Tralfamadore is of greater value to me because it has stimulated my thinking more than Pluto has.

CREATIVITY VS. COMPETENCE

Many teachers place a high value on competence to perform certain tasks, and students are evaluated on their ability to do them. This is clearly called for when skills such as flying an airplane are involved. No doubt our civilization would collapse in the absence of a great number of individuals competently performing essential tasks. There is however, a danger in extrapolating this need to all areas of education. An interesting exercise is to start making a list of the things a competent astronomer would know. We might agree on the ability to communicate in some language and the skill to do simple arithmetic, but beyond that I can think of no universally applicable items for the list. This is completely compatible with the statement that all competent astronomers know how to do something extremely well. This viewpoint can indeed lead to a new definition of competence—the ability to do well whatever the exigencies of the moment require that you be doing. This is competence defined in relation to living life as it comes and not with respect to arbitrary standards. Contrast this with the ease with which our society defines competence by scores on tests which demonstrate the capacity of the individual to cope with artificial situations. Albert Einstein said “Imagination is more important than knowledge.” I don’t know the context of the quote, but I believe it applies to all situations considered in this article. We hardly ever make decisions based on total knowledge of a situation, and the ability to imagine the possible consequences is vital to decision making—a talent hardly ever cultivated in those we teach. One unnerving thing about the creative process is that you are never sure what will come of it, and many people are nervous about surprises in an educational setting where there are always “right” answers. Perhaps we should be less concerned with products and more concerned with the exercise of the process. There is something wonderful about looking at a problem in a really new way even if the approach is fruitless. If great value is placed upon arriving at the right answer, students will be much less likely to try, to fail. For this reason I am partial to activities which have no predetermined answer at which the students should arrive. One way to move toward greater possibilities for creativity in teaching is to realize the value of ambiguity. Lack of ambiguity stifles creativity—if there is no vagueness to allow room for maneuvering, then students will do very predictable things, and I find that dull. Nature is the real master of ambiguity—her problems are not even presented as problems—we create the problems through the exercise of our own imaginations. If we present a student with a completely specified problem with values for all the parameters, we are giving him a problem solving opportunity in which he cannot fully exercise his imagination. There is something pathetic about a person who has become quite skilled in solving problems posed by other people. The creation of problems from the ambiguity of nature is a greater feat.
than the solving of them; yet we place
greater emphasis on the ability of
students to solve problems, probably
because it represents an easily mea-
surable skill on which grades can be
assigned. A classic example of an
ambiguous problem is the Zen riddle
(\textit{e}g., what is the sound of one
hand clapping?)

These problems demand creativity
to make any progress toward their
solution. The first obstacle in con-
fronting an ambiguous situation is how
to shape it into a problem. There will
be many ways to do this, and a
student will experience indecision
before selecting a problem. In that
experience may lie the greatest value
of the exercise. In my experience, the
first time a student is put in the
position of confronting the universe
(and formulating a question based on
it) is when he selects the topic for his
Ph.D. thesis. This is well known to be
traumatic process, and perhaps bet-
ter and easier choices would be made
if problem posing were a talent cul-
tivated in the educational process.

PARADIGMS

Many professions have a mode of
operation to guide thought. For exam-
ple, the medical and legal profes-
sions have codes of conduct which govern a
practitioner’s approach to a patient or
client. Such standardized approaches
to people or problems is called a
paradigm. If a paradigm exists for the
education profession, it has escaped
my attention. Some teachers operate
with a guiding ethos derived from law
enforcement which views society as a
composision of good and bad—with
the bad suppressed. Others adopt a
military attitude where regimentation
is paramount and drills good for the
soul. Both are based upon coercion
and deny the student the opportu-

My view of education is a combina-
tion of two paradigms, the physician
and the chef. A common medical joke
concerns flunking one’s physical exam.
That is funny because it is ridiculous—
physicians don’t give a letter grade
based upon blood pressure. They help
you out by diagnosing your ills and
prescribing measures to treat them. I
see the parallel quite simply as: you go
to the doctor if something hurts—you
go to the professor if your lack of
understanding bothers you. I would
enjoy having students deal with me as
they would with a physician. They
come to me because they have a
problem in astronomy that perhaps I
can help them with. I do what I can to
help them out, and then I am paid for
my services. The question of grades or
of failure never arises because in that
context it makes no sense. The student
desires the experience, not an accumula-
tion of credit toward a degree.

Unfortunately today’s educational
system is not set up this way.

If the paradigm of the physician is
the ideal, then that of the chef is the
possible. I like to make the analogy
between my course and Alice’s Restau-
rant where you can get anything you
want. All the astronomical dishes are
set out as at a great buffet and the
students are invited to come and try
anything that looks appetizing. Ap-
petites will vary, and some will get
indigestion from the specialty of the
house, but everyone will be making
their own choices. My role is to show
students what is available and encour-
ge them to try things. I also set an
example by gorging myself on every-
thing in sight. This approach contrasts
with the philosophy characterized by
“Eat your spinach, because it’s good
for you.” Maybe the kid is allergic to
spinach.

It is difficult to distill an educa-
tional philosophy into a few central
ideas. In spite of that, I will set forth
my axioms and some of their implica-
tions. As in the case of most good
ideas, these have been stolen from
various forgotten sources.

1. People are more important than
anything you can teach them. Those in
academic positions may be tempted to
place dissemination of the dogma of a
discipline ahead of promoting the
growth of the individual human beings
in their classes. I do not want to
downgrade the importance of the
body of knowledge and understanding
amassed over the centuries— I just want
to put it into perspective. An unfor-
tunate consequence of putting infor-
mation ahead of people is that it may
lead to looking at a student who is not
learning the required information as if
there were something wrong with him.
Too often have I heard “X is a good
student” as a value judgment of an
individual. What was really meant was that X was making rapid progress in assimilating a portion of a body of knowledge deemed important by the instructor. Aside from being an existential statement of a type I can’t handle well, it is tied into a value system which asserts “your value to humanity will be enhanced if you learn all that I know.” If I emphasize learning those things I know and like about astronomy, I am inviting the student to be a poor copy of me. I would rather provide the opportunity for that student to realize his own potential. I try to avoid making evaluative statements about the relationship between a student and some knowledge I happen to have in my head or on my bookshelf. Relationships which promote effective communication cannot be built on judgmental statements. It is also difficult to care about someone we have labeled as inadequate to cope with the subtleties of a science. How then are we to relate to students if not in terms of their mastery of content? To me a meaningful statement to make about a student might be “I enjoy being with X.” All too few astronomy professors would use terminology like that in talking about their students, yet that is the way we talk about our peers. One important reason for this is that teachers may never get to know their students. That situation is one of the tragedies of contemporary education. If I were to loosen personal contact with my students, the opportunities to learn from each other in all the ways that make education count would be lost.

2. Nothing is so important that everyone needs to know it. Many educators, especially the writers of textbooks, have concluded that in order to be educated, a person needs mastery of a certain body of knowledge. I do not agree. That conclusion led to the concept of general education which flourished during the last three decades and is now finding it increasingly difficult to survive. What such sets of requirements tend to be are statements concerning what one individual found helpful in living his life. To infer any kind of universality from this is ego exercise. What a person does need at any point in life is the imagination, knowledge and compassion to deal with his current problems—of whatever nature they may be. If these attributes are present in sufficient quantity then success follows. If they are not, failure is the outcome. If future problems are predictable, then specific training to meet them would be defensible. The difficulty of predicting the future, in respect to everything but eclipses, is well known. To say to someone that they will have to know a certain technique or bit of knowledge is to presume possession of a nonexistent crystal ball.

For reasons of history and faculty convenience, interesting topics are often treated in advanced courses protected by a wall of prerequisite courses. The rationale for this is that an understanding of certain concepts is necessary to deal intelligently with the topic. This may be true from the professor’s standpoint, but not for students who have their own way of looking at things. I believe that anything in astronomy can be discussed with interested freshmen at some level of sophistication. It is the problem of the educator to figure out how to do it. Fortunately some excellent examples are available—e.g., Kaufmann’s Relativity and Cosmology. Student enthusiasm is precious. To frustrate it with unnecessary obstacles is counterproductive to the educational process.

3. People grow by making decisions. This brings us to a further consideration of values. What do educators want most to see happen to students? To me the answer is not—“end up knowing a whole bunch about astronomy.” That may happen, and I certainly have nothing against it. My primary concern, however, is to help immature human beings evolve into adults able to deal successfully with the world and perhaps capable of enriching the world by their presence.

Many students go through college without ever having to make a decision more profound than where to go to drink beer on a Friday afternoon. Major requirements leave no room for electives, general education courses are specified, and in most courses the times to read what books and write which papers are carefully prescribed by the professor. I am fully aware that this is not descriptive of all courses and majors and schools, but I have the impression that in the continuum that runs from faculty decision making to student decision making in the operation of courses, astronomy classes tend toward the former. In any class where the professor makes all the decisions several things may be communicated to the student: a) I (professor) know what is good for you (student); b) I do not trust you to make decisions about your education; c) I am responsible for your education, so I’m going to make sure it’s done right. These are all messages I rebel against, but they are constantly transmitted in courses ranging from accounting to African history.
An educator can profitably spend some time reflecting upon and ordering his priorities. Is the primary goal to teach astronomy or to teach people? These are not mutually exclusive, but one must outrank the other. It took me about three years of teaching to decide that people come first. I hope this article encourages people teaching astronomy or whatever to try some of the things I tried—probably with the same misgivings I had—and see how it feels.

In the next issue of Mercury, Dietz concludes his article with a discussion on concrete examples of his approach, specific classroom activities, the role of questions, tests, and grades and the real and illusionary difficulties in putting his philosophy into practice.
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IN
ALICE'S
RESTAURANT
PART II

by Richard Dietz

In our previous issue Dietz discussed his basic philosophy of education, the problem of values, creativity and competence and the overall objectives of his program. In this issue he concludes with a discussion of concrete examples of his approach, specific classroom activities, the role of questions, tests, and grades, and the real and illusory difficulties in putting his philosophy into practice.

CONCRETE EXAMPLES

“There are many ways of teaching. Not all of these are ways of helping people learn.”

—Anon

With a few notable exceptions (e.g., Donat Wentzel in AIP) articles about education in astronomy concern subjects like how to make a planetarium out of your wastebasket or perhaps how to derive Kepler’s Laws using only a toothbrush. A few of these I have read with interest, but none have had much impact upon my behavior in a classroom. What I will now do is outline my approach to teaching a first course in astronomy.

The first and most obvious ingredient in this educational recipe is for me to know all I can about astronomy. Whatever I know now is the product of working on this task for about 25 years, and it still occupies a notable part of my time. I am my students’ principal resource. While I freely admit my ignorance when the occasion calls for it, I would rather not have to do that constantly. My usefulness to my students resides largely in my knowledge, my imagination and my ability to do things. The more I am the more they can hope to be.

However, a student’s desire and my expertise will generate nothing if there is no communication. Communication is verbal, nonverbal, written, pictorial, etc. It proceeds by word, action, mannerism, inflection, etc. All of these channels are in continuous operation with messages constantly being exchanged between people both intentionally and unintentionally. Students seem to be more sensitive to these communications than professors, so I suggest that professors need to be more aware of them. With tragic ease we can send a message to a student which will be perceived as indicating that he is a lower form of life. What do I advocate? That all channels of communication be open to the maximum extent, with opportunity for misunderstanding minimized. The most familiar communication channel is speech, so I spend a lot of time talking with students. I emphatically

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do not mean time spent lecturing to a class. To be dogmatic about it, the most effective kind of communication takes place when two people are responding to each other. For this reason I seek one-to-one situations. One of the first things I tell my students is that there is only one requirement in the course—that they spend about 20 minutes a month talking with me alone. I want to come to know my students, and these talks are explicitly intended to be practice sessions in two-way communication. Usually nothing of great moment is discussed, but it provides an opportunity for people to say what is on their minds with a minimum of external influences. It also makes it easier for students to talk with me in class, after class, during lunch, in bars, during labs, etc. Sometimes they even want to talk about astronomy.

This makes for a lot of work, but I feel it's worth it. At the end of the quarter I ask students to write essay evaluations of the course. A few months ago one girl wrote: “This is the first class in my college career that I have asked questions during class time.” That’s one of the nicest things anyone has ever said about me! I don’t know how much astronomy she learned, but she made great strides in being able to direct her own education. Should astronomy instructors be concerned with things like that? Everyone has to answer that question for themselves. I am convinced that you can get more done working with people you can talk with frankly and frequently. In many of our varied roles that sentence only states the obvious. Why then is it so often ignored in education? Traditional classrooms are like transistors—information flows in one direction only. That’s good if information transfer is the main concern, but I like to leave that to the printed page so I can do more exciting things.

For those who agree that lots of two-way communication is desirable in education I would like to describe some of the techniques I utilize. I do not claim to have invented any of them, and I can only say that they work for me. For most of us speech is a rather automatic process. For our words to have the desired effect we need to be very aware of our speech—what we are saying and how we are saying it.

**DON'T ASK QUESTIONS**

I have spent a few years listening to what I say and watching to see how it is received. That exercise led me to effect conscious changes in my speech patterns. All that means is that by exerting a little mental discipline one speech habit is exchanged for another. What then are my tricks of trade? If I could give you only one, the choice would be easy. Simple to state, but capable of producing mental trauma in many teachers it is: “Don’t ask questions.” To really experience what this means there is a simple exercise anyone can perform—try to go through an entire day without asking questions of anyone about anything. Probably only practicing hermits will find this easy to do. Human speech consists of statements, questions and expletives which usually turn out to be terse statements. I assert that questions are threatening objects and that they are unwarranted intrusions into another person’s head. Since the beginning of time, it seems, students have been cowed by the prospect of the shame associated with not knowing the right answer to a question. This has been a monstrous hindrance to communication. Millions of students, myself among them, have cultivated the art of being invisible in class so that they would not be called upon to answer questions. So a question then, at the cost of engendering fear and resentment, only determines how another person at a particular point in space-time responds to a particular external stimulus. To me that is not worth knowing.

I know that in general conversation, questions frequently annoy me. Others I have discussed this with share my feeling. My personal observation is that in approaching students, statements often open them up while questions tend to shut them up. In some stereotypes, professors seem to be paid to give lectures and then ask questions about them or about the reading. Certainly this may be done, and I have done it. But I wouldn’t do it again after experiencing the change in mood that comes over a class when questions are avoided. For me the atmosphere changes from negative to positive, students talk more and are more open with me. Things don’t become ideal overnight, but the
motion is in the right directions. We are all human and fallible, so occasionally a question creeps into our discourse. This really does no great harm, and perhaps it adds some variety. I really don't intend to abolish the question mark completely; I just want speakers to become aware of the positive advantages statements have over questions. There are, however, two kinds of questions which I try very hard never to ask. The first kind arises from my understanding of what the function of a question should be—to find out something you don't know. I therefore consider it unnecessary to ask a question if I already know the answer. If I ask a student a question it will be to acquire for myself some needed information. Since I already know the speed of light no student need be concerned that I will ask him for that value. In contrast, I might well ask him what exposure time he used for a photograph of Saturn. Five years ago I would ask questions of students in class and always feel a little ridiculous doing it. I finally discovered why—I already knew the answers.

The second kind of question I avoid is harder to guard against and has more serious consequences. I try never to ask another person a question that begins with the word "why." The standard English interrogatives (who, when, where ...) serve to introduce most questions. Of these, "why" is the one that calls upon a person to justify his activities and almost automatically triggers resentment. Sentences of this type frequently elicit meaningless replies such as "I felt like it." To me the reason for this is clear. Ask a meaningless question and get a meaningless answer. Hardly ever do people really know "why" they do something. They just do it and later offer rationalizations to themselves or others if called upon for justification. Furthermore, I feel that another person's internal motivations are none of my business. Now when someone's actions confound me I merely express my surprise. Perhaps this elicits an explanation. If it does, the response will probably be of some interest to me. To notice this effect for yourself try to become very aware of your own reactions when you are asked "why" questions. There is another side to this which has to do with ultimate causes. The question, "Why do stars shine?" poses no personal threat to anyone. However, I see that question as theological and not astronomical. I think I know how stars generate energy, but from a philosophical viewpoint that has nothing to do with the previous question.

THE BENEFITS
OF CREATIVE CHAOS

I believe in the beneficial powers of creative chaos. Like the mythic molecules in the primordial soup which randomly collide until they generate DNA, students perform a random walk toward education if they spend enough time in a rich and stimulating environment. I try to provide vast resources and frequent activities, and the students immerse themselves in this mix to the extent they feel appropriate. If this sounds like trying to run a three-ring circus, that's the way I feel sometimes. I want astronomical things to be happening at all hours of the day and night and in lots of different places so students, as well as having a choice, will have to make a decision about how they are going to spend their time. When I think about how to make my courses better, I think about how I can enlarge the spectrum of activities which can be made available to students to participate in. The passion I have for arranging activities stems partly from my conviction that the three hours a week that a class meets in an assigned room constitutes one of the least important aspects of a course. Where is it that people learn things? My experience, both as student and teacher, leads me to believe that very little is learned by listening to a lecture and taking notes on it. I think that learning takes place while people are actively engaged in doing things which require more commitment than sitting in a class. One learns while reading a book, talking to others, solving a problem, operating equipment, analyzing results or just browsing in the library. Students accustomed to educational experiences requiring only their passive participation often experience frustration in my classes. I see that difficulty as natural and a learning experience in itself.

CLASSROOM ACTIVITY

Having minimized the importance of classroom activity, I proceed to use it in a variety of ways. Students who come to class will find (a) some time each meeting devoted to scheduling activities—who wants to do what, when and where, (b) about one film per week, (c) an occasional formal lecture devoted either to something I'm particularly interested in or a requested topic, (d) considerable attention given to current events such as NASA activities or recent astronomical discoveries, (e) lots of time to ask questions about whatever is on their mind, (f) occasional discussion of
educational theory and practice, (g) some activities aimed at developing awareness and improving communication, (h) show-and-tell sessions for students with tangible results, (i) brief demonstrations and explanations of various things I have been lying around, (j) an opportunity to utilize the multitude of resources to be found in the classroom, and (k) a chance to talk with whoever else is there. This list does not encompass all possible activities, but certainly covers more than 90% of them.

There is a lab at a scheduled time and place where there are telescopes and a lab instructor. The lab is run on an open basis with lots of different things going on simultaneously. At a given instant students may be photographing Saturn, learning constellations, trying to find some asteroid, looking for the North Star, eating a pizza, looking for another Messier object, and playing with a dog. Sometimes the current lab assistant accompanies all this on his guitar. On the other hand, when there are clouds or low temperatures very little happens, except in the darkroom where developing and printing goes on most days and nights. I try to have the lab open with competent supervision a minimum of 8-10 evening hours per week for the benefit of whoever shows up. Activity on good nights is equipment-limited with lines of people waiting for time on a 8 or 10 inch telescope. The lab is also open sporadically at midnight or 4 A.M. whenever something interesting is happening or just to look at the morning sky.

In the laboratory I emphasize working with the sky. This may be just learning what is where and looking at it, or it may involve photography which is always one of the most popular aspects of the course. I try to keep the students constantly aware of things like occultations, Algol minima, sunspot groups, meteor showers, asteroid apparitions and phenomena concerning the satellites of Jupiter so that they may do something with them. Some people like to study planetary features, others collect Messier objects—I just like them to spend time with a telescope. There are indoor labs a few times during a quarter. The most popular subjects for these seem to be navigation and calculating horoscopes.

The subjects discussed in class are determined largely by student interest, and are quite predictable. They want to know about extraterrestrial life, black holes, astrology, UFO’s, time dilation, excessing the speed of light, quasars, the origin and structure of the universe, planetary exploration, what makes meteors showers and why Comet Kohoutek didn’t work. So I spend considerable time talking about these things and try to stimulate some thinking and discussion. I enjoy this because these topics are of interest to me too. Of course, this is all ice cream and no spinach, but those involved seem to enjoy it and spinach is readily available for anyone who wants it. I have arranged for all introductory and intermediate astronomy courses to meet in a unique room. I have covered the walls and ceiling almost completely with things to look at or read. It is an attempt at total visual immersion in things astronomical—only the floor remains in its original state. In addition to photographs, posters, cartoons, news clippings, a giant graph of sunspot activity, a number of readable periodical articles and a model of the current configuration of the solar system which covers the entire ceiling, there are about 200 paperback books for students to browse through or check out and files of seven elementary astronomy periodicals. This is augmented by a museum of paintings, poems, sculpture and other assorted artifacts produced by students and which I found particularly pleasing. The media range from stained glass to string. I enjoy the experience of being able to point at a photograph illustrating what I am talking about or to pull off the wall an article explaining some aspect of a student’s question. I look at that classroom as a giant box of resources which I put together and continually improve and update in an effort to facilitate learning about astronomy. It is the main arena in which I perform, I enjoy being there, and I depend upon it as a very important component of my teaching activity. It is easy to tell that many students enjoy spending time there too. It is quite a contrast with other sterile classrooms around the campus.

Second in popularity only to looking through telescopes as a student activity is reading. I’m not sure if this is because they enjoy reading or they are so used to doing it for other classes. The world is full of books, but most students depend upon three sources—the university library, the classroom collection or the university bookstore where about a dozen paperbacks are kept in stock as “recommended” for my courses. In my personal scale of values, reading ranks behind doing as a profitable way to spend time. This certainly does not prevent me from suggesting to students that they read extensively, as it is an excellent way to acquire know-

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I have never come across a textbook I could not put down.

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ledge and there is not enough equipment around here for everyone to be doing something.

I also want to emphasize the fact that there are lots of interesting books around which have something to do with astronomy, and which are fascinating reading. They are not normally recommended to students because they are perceived to deal with illegitimate astronomy as opposed to the legitimate form found in texts. To cite a couple of examples, Vonnegut’s *The Sirens of Titan* and St. Exupery’s *The Little Prince* both deal with folks running around the solar system doing rather unscientific things. In spite of that drawback my students and I have found both of them to be delightful. I do not intend to argue the legitimacy of such literature. I will only note that I feel fortunate to be associated with a field of study which lends itself easily to such imaginative and poetic expressions. That some of man’s great fantasies are played out in the night skies is nothing to be ashamed of. On the contrary, astronomy educators should exploit this fortunate circumstance.

I hope these few paragraphs have given an adequate description of what I do in an introdutory astronomy class. The perceptive reader will have noticed that certain significant things have not been mentioned. That is because they are not significant. However, sometimes things are well described by negative statements. It is thus time to dwell upon things which I do not do.

NEVER TELL ANYONE WHAT TO DO

I feel the one central dogma from which the others follow, is that I never tell anyone what to do. Adherence to this simple rule prevents me from doing any number of other things such as requiring a textbook, making assignments, giving tests, etc. I see these things as only excess baggage education has acquired over the past decades. Doing away with them just removes some of the obstacles that have been placed in the way of people who want to learn something. Let us consider some of these obstacles in more detail.

Few things have been so inimical to education as the textbook. In spite of the best efforts of the writers, textbooks are not exciting to read. I have never come across one I could not put down. They make possible, indeed encourage, that sine of education, the survey course. That opportunity to learn more than you want to know about most things and less than you want to know about others is traditionally imposed upon freshmen and other defenseless persons. It is far better to have a large number of courses about specific topics from which the students may choose. The second major problem with textbooks is more of a philosophical nature and I present it as something to think about rather than a strongly-held conviction. A textbook, by virtue of its finite length, arbitrarily defines the boundaries of a field and may convey the erroneous impression that nothing lies beyond. By virtue of its organization, it imposes, often arbitrarily, an order upon the subject.

My concern was well-expressed by John C. Gardner in *Grendel*—“All order, I’ve come to understand, is theoretical, unreal—a harmless, sensible, smiling mask men slide between the two great, dark realities, the self and the world—two snake pits.” A bit extreme perhaps, but beautiful. It is an idea that assaults the mind inclined towards order. Those words could well be placed as a kind of philosophical surgeon general’s warning on the covers of all textbooks.

TESTS

It’s been about three years since the last time I gave a test. Life seems to go on without them. A test is an empty exercise which takes up both my time and that of the students. I care very little about how much a student knows, and thus I am not likely to expend any effort in finding out. I do care what students can do for perhaps they might suggest projects they can undertake to our mutual benefit. To find out about such talent I need only ask them. It is important to be aware of this dichotomy in knowledge. Knowledge of only those things which one might confront on a test is fragile and sterile. Knowing how to do something, be it develop film or repair a television set, allows for concrete actualization. I always emphasize to students the satisfaction to be gained from holding something in their hand and saying “I made this.”

Tests do serve one useful purpose. They tell the interested student whether or not he knows much about some topic. I can usually answer that question to his satisfaction by talking with him for five minutes after which time he becomes clear that he knows less than, as much as, or more than I do.

To test general astronomical knowledge I have prepared a series of multiple choice tests available, together with their answer keys, to anyone at any time, and I never know the results. There is one kind of test I like—the
kind that is assigned by the student and graded by nature. When the film comes out blank that is nature's way of telling you that somewhere along the way you made a mistake. Any elaboration of that on my part is pointless—nature said it all. At that point one gives up or takes upon himself the new assignment of trying to figure out just what it was that went wrong. Somewhere in there is the reason why astrophotography appeals to me so as an educational tool. It is difficult to bring success and failure into the reading of a book, but a photograph of Jupiter is different. If it did not come out well, no arbitrary value judgment on the part of the instructor was involved. If it is good, nothing I can say will make it any better. Furthermore, no matter how good it is, it can always be improved. I would like to find more activities, possible with modest equipment, which share these characteristics—success and failure are possible and nature alone determines the outcome.

**GRADUES**

Having put it off as long as possible, I must now say a few words about grades. I have no use for them. If someone had set out to invent something which would destroy the urge to learn, breed fear in students, demolish trusting relationships and waste the time of both student and teacher, they would probably come up with something like grades. It would simplify my life somewhat if I had nothing to do with the giving of grades, but it seems to be a condition of my employment. Faced with the necessity of making the best of a bad situation, I have tried to devise a procedure which will not be damaging to those involved and will perhaps serve some useful purpose. Since I think grades are meaningless, it is of no importance to me what grade a student receives in a course. Even if I were inclined to think about them, I am hampered in many cases by a severe lack of knowledge concerning how much work a student did in the class and what he was able to accomplish. The student, however, knows what he did, and furthermore he is often concerned about what grade he will get. Grades, unfortunately, are still of some importance with regard to staying in school, qualifying for scholarships, and gaining admittance to graduate school. As I see it then, the student is in the best position to assign the grade. At the end of each quarter I spend some time talking with each student about their reactions to the course and what they got out of it. I then ask, “What do you think is an appropriate grade for you in this course?” An “appropriate” grade is one which takes into account all factors which may influence the outcome. It is up to the student to decide what these factors are and what weights to assign to them. I am careful not to use the word “deserve” in this context because the word carries, for me, some connotation of a slave-master relationship. The word “want” is also to be avoided for the reason that our wants usually do not involve considered judgments. Most students want to get high grades, be popular and have lots of money. My intent is not to feed such daydreams.

I have no desire to turn the grade-assigning session into a confrontation, so whatever grade the student selects I enter without argument or comment, and the matter is closed. This avoids the distasteful aspects of union-management negotiations wherein both sides start with inflated demands and work toward a middle ground. Grades are just not worth that much trouble. By this mechanism I see to it that the student has the opportunity to take a few minutes for a critical assessment of his strengths and weaknesses as revealed by what went on in the course.

When grades are determined in this way they tend to be high. A typical class will produce a few C’s, several B’s and lots of A’s. I have no desire to calculate an average, but it is probably around B+. History shows rare instances of students deciding upon a D, but no one has yet taken the ultimate step of flunking himself. Is it grounds for concern that many of my students get high grades? Someone, somewhere, may be worrying about it, but I’m not. It seems to me that if education were truly dedicated to the idea of promoting learning, then the excellent teacher would be marked by having all of his students get A’s. I have written enough about this depressing subject. With any luck, when I wake up tomorrow grades will have disappeared from the face of the earth, for, in spite of all my efforts, they still form a barrier between me and those who want my help. This completes a rather candid outline of how I teach an introductory astronomy course. All is not sweetness and light, however, and I feel it my duty to describe the problems I encounter.

**REAL DIFFICULTIES**

I divide all problems into real and illusory and deal with the real ones first. The demands on my time are great. That this is the result of a conscious choice on my part does not make it less of a problem. It is quite easy to spend an entire day talking to
students with time out only for lunch. My life style has had to change to accommodate the demands for my time. It would be delightful to have lots of free time, but I see no way to avoid the fact that to work with large numbers of students on an individual basis requires many hours a week. One of the things that makes this all possible is that I have to devote no time at all to correcting homework assignments, making up tests, grading tests and other similar activities which professors often engage in.

The size of classes is very important in this regard. There must be an upper limit to the number of students I could work with in this model, but I don't know what it is. In recent quarters I have had about 130 students in all classes combined, and I feel up to working with 150. That is about twice what I feel is the optimum number and represents a concession to the great demand which exists for astronomy courses.

Teachers usually feel most comfortable when talking about those things they think they understand. For this reason when an instructor determines the content of a course it is usually confined to what he sees as his area of expertise. When the students are determining the course content, questions and problems may arise from any area of human knowledge, and the instructor must feel comfortable while admitting his total ignorance in some area. In this situation any pretense of omniscience is quickly demolished.

When dealing with students on a personal basis, one's natural likes and dislikes come into play. In spite of all my attempts at impartiality, a couple of months is quite enough time for me to string my students out along the spectrum from those I love to those I just can't stand. The personality conflicts with those at the latter end present the greatest problem. I offer no solution here. What I do is examine my feelings toward the person and try to determine what it is that makes me respond in the way I do. Sometimes this gives me an insight which helps me cope with the problem better.

Pressure from one's peers can be a sticky problem. Those who try something different are often suspect. The criticism I hear about the way I run my classes usually involves something called standards or reputation. I'm not sure what that's all about. The best possible response to such criticism is success.

The students have real problems too, and they are not the same ones which arise in classes taught in the traditional manner. They find themselves in an unfamiliar reward system, and this generates insecurity about what they want and what they should be doing. They wonder if I really care about them at all since I do not do the normal things that professors are supposed to do. It takes time, sometimes as much as a month or two, for these problems to be resolved.

**ILLUSORY DIFFICULTIES**

All of these problems are real and have to be faced. For some people, like me, the rewards are worth it all. One thing I certainly don’t need is to have to devote some of my energy to the solution of problems which really don’t exist. I call these problems illusory because if you look at them in the right way they disappear. The prototype of these problems is the need perceived by many instructors to “cover the material.” In most cases this need is connected with the use of a textbook although it may also apply in the case of a set of notes developed by the instructor over past years. Another particularly pernicious form involves the use of syllabus prepared by a committee and meant to apply to all sections of the same course. All of these cases concern the existence of a predetermined agenda which is to be adhered to for the presumable reason that it will be of some benefit to someone. Some degree of inadequacy on the part of the instructor is then associated with his failure to address all of the points included in the agenda. In the last week of every quarter I see frantic efforts being made to finish “covering the material.” Indeed, I once did the same thing myself. The proper response to this situation is not to talk faster, it is to do away with an agenda whose necessity is illusory.

There are other illusory problems. One concerns the duty of the academic profession to “weed-out” poor students as if somehow society needed to be protected from them. I recognize no duty to act as a screening device to ease the burden of industrial recruiters. I am working towards the demise of the university as an obstacle to be overcome by students looking for a place in society. I want that obstacle course to become an experience to be enjoyed.

Then there is the problem of preparing students for a “higher-level course” in the subject. Sequences of courses with prerequisites dangling from them abound in college catalogs. Their presence is due to the ascendency of the linear theory of education, the evidence in support of which is at best ambiguous. There is no reason to learn how to spell “cat” before learning “rhinoceros” if the latter is what you are interested in. In the advanced course it frequently turns out that the students remember nothing from the prerequisite course or that the learning which took place is never called upon. For admission to my advanced courses I am tempted to require “enthusiasm, curiosity, and imagination,” but I don’t know if I could get that approved. It is noteworthy that lower division courses often seem designed to suppress these qualities in students.

I have been sharing with you some thoughts concerning the problems I encounter in my attempts to be a good astronomy teacher. These problems do bother me, but not nearly enough to trade them in on the old set of problems I had when I was teaching in a more traditional fashion. I would like to make it clear that I do not advocate that everyone teaching astronomy start doing what I do. I believe in the validity of a great variety of approaches, and each instructor has to find out what works best for him.

I am optimistic about the future of higher education, astronomy in particular, if drastic changes are made. Institutions must become responsive to the consumer. Education must cease to be the only business in which the consumer is usually wrong. Instead of telling the students what they need, universities should be helping individuals mature to the point where they can recognize their own needs. Universities will then become very busy satisfying those needs in people from all segments of society. I am confident that most human beings would decide that they want to enlarge their awareness to include more of the wondrous things to be found in our universe.