Education of soil scientists

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THIS requested paper is based mainly on about 4 years of classroom teaching at North Dakota State University in the early 1930's. This has been supplemented by teaching in the USDA Graduate School, by brief experiences in many American universities with students in both the sciences and the humanities, by technical assistance abroad, and by much staff training.

At North Dakota I was also advisor for many students majoring in fields other than soil science, because at that time each student could select his advisor anywhere in the College of Agriculture, not necessarily from the department of his expected specialization.

I assumed that each student should have opportunities to get the most he could out of college. Certainly professors should not work only with those of high aptitude. A great many important jobs that need to be done well do not require a Ph.D. degree.

In fact, I think some universities need to rediscover their undergraduates. They, too, are people. During the 1940's and 1950's several universities invited me to join their soil science staff. Most explained that I could have my own graduate students and research. I never did accept but always explained that should I do so, I should want mainly one course. Which one, they would ask? I replied: "The first course in soil science the students have." "Why that one?" "Because I should like to have the undergraduates first so they do not find out that soil science can be very dull and uninteresting." Actually the teacher of soil science has more interesting examples of why and how people around the world live as they do than most others.

Each student needs individual advice for a plan at the university. As he and his advisor work together the plan can be modified. Some of the most highly motivated students may substitute higher mathematics or other advanced courses for the less challenging required ones, or at least they should be permitted simply to write the final examination of such courses for credit. Some others may need to be asked to repeat a course. It was a continuing challenge for me to try to work out the best plan with each individual undergraduate student and to adjust as we went along. I should add that my advice to them depended on the professor for a course as much as on its title.

Most, but not all, of my students in soil science took calculus and some went on to differential equations. Nearly all had physical chemistry, plant physiology, and one or more courses in bacteriology, partly because the professor was also good in advanced organic chemistry. For a year or two, I had to teach plant physiology before a good professor for it was added. Most of the time I had to teach geology, since there was no professor. I did the best I could, especially with the Pleistocene. All my students had one or more courses in economics and several took courses in foreign language and advanced English composition.

Few of my students were good general readers when they came. Most of what they had read they had been quizzed on—the Bible and their school textbooks. They read slowly, so reading seemed a bit dull for free evenings. Yet we all know that a high percentage of what we learn comes from reading.

Some required reading of upper classmen in soil science included Sir John Russell's *Soil Conditions and Plant Growth.* Students read and were examined on those parts of John Stuart Mill's *System of Logic* that dealt with names, properties, classification, and fallacies. These were discussed in seminar with illustrations from current books and

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papers in soil science. When a student was given a paper to review in seminar, he was never told in advance how much he was expected to emphasize important contributions or how much to discover the fallacies. (Much later I learned that Mill's *System of Logic* was also an important guide for the Dokuchaev school of soil science.)

LEARNING FROM PEERS

It was fortunate that I had a small extra room. Just outside this room I had a fair library, partly college books and many of my own. Within the room were tables, chairs, and maps of the world. For courses that I gave, I handed the students a list of "review questions" any of which might appear on an examination.

The late Dean Harlow L. Walster was very cooperative and let me give each soil science student a key to the building and to my office. Nights that I drove by, the lights were commonly on to 10:00 p.m. Most of my students learned a great deal from their peers in arguments about the answers to the review questions. I suspect that some of them still have sets of the questions and answers.

READING

With my students, individually, I encouraged reading the sciences, poetry, drama, fiction, history, philosophy, and geography of the world population. Much of the geography came from books not titled as such. I also encouraged reading about religions besides their own and the history of soil science.

In the autumn of 1931 I had a lucky accident. A national meeting of the University Professor's Association followed the meeting of the American Society of Agronomy in Chicago. I attended both. At an intermission for lunch I found myself seated at a table for two with an elderly professor of psychology from the University of Chicago. (Later my friends told me that it must have been Professor Will James.) I told him of my problem with students who read little. He replied, "I've had students like that. But you can cure them, and only you can do it because you know them. Suggest a book to the student that you know will interest him. But never ask him a word about it unless he asks you something."

I followed his suggestion, and it worked. Nearly all came back for other book suggestions. Later, I had a reading list mimeographed and gave each student who inquired a copy with one book checked at a time. Most became good general readers across the board.

After considerable urging, I agreed the list could be published (J. Amer. Soc. Agron. 32:867-876, 1940). In the meantime I have made many revisions, the last in January 1971. The list is more helpful if one talks with the student in advance.

UNDERGRADUATE STUDENT SEMINARS AND THESES

Near the end of their sophomore year I worked hard to get for my students who were majoring in soil science summer jobs related to soils in North Dakota or elsewhere. Their course work took on much more meaning after working with soils in the field. Also I allowed those who wished to do so to submit an undergraduate thesis for credit. This could be based on field work, such as experimental plots or soil survey, laboratory or greenhouse studies, or some combination of these.

I emphasized in my teaching that education was a lifetime undertaking and that as an undergraduate student, or even in graduate school later, they were getting only the tools, skills, and habits for an education. This would follow considerably later.

In the written and oral examinations I tried to avoid receiving only repetitions of what the student had been told or had read in the text. I tried to find out what he had learned that he could use from his other courses and from his summer work.

In our seminars we did a lot of this kind of probing. We attempted to diagnose problems in producing field, horticultural, and industrial crops, including the many interactions among practices and among those combinations of soil properties that made a soil of a certain kind. Similarly we discussed the soil problems of highway construction, forestry, land classification for tax appraisal, rural zoning, and community development. A few of our seminars dealt with soil problems and potentials overseas.

Unhappily I was ill prepared then on many aspects of the history of soil science. I told my students of the work of Way and Gedroiz on the adsorption of cations. Then I did not know that Edmund Ruffin, a Virginia farmer and the first great soil scientist in the United States, had proved this in his barn before publishing the first edition of his great book, *Calcareous Manures,* in 1832. Yet I did read to them from Columella. Columella, Ibn-al-

Awam, Arthur Young, John Evelyn, and many of the other great masters of farming, forestry, and gardening were excellent observers with good memories and had explained firm principles that were confirmed many years later on experimental stations and in laboratories. I have also learned that even illiterate but wise farmers came to about the same conclusions with the "cut-and-try" method on similar kinds of soil.

OBSERVATION

Certainly the soil scientist needs good laboratories and controlled field experiments on known kinds of soil. But to make full use of them he needs to be a curious observer and try to understand what he sees. With good background training, including reading, observations, appreciation of the principle of interactions, and a faithful notebook he can learn a great deal to help him diagnose problems of soil use and management.

Soil-use problems are related to many geological, climatic, social, cultural, and economic situations as well. Hopefully on the farming side, the soil scientist can distinguish deficiency symptoms of plant nutrients from the effects of fungi, insects, pollution, and other cases.

Many of these problems can be taken apart in field seminars. A professor can help the student appreciate the complex relations of his science to many others. I recall having an excellent undergraduate student to whom I insisted on a course in economics. He objected and said, "I hate economics." I replied, "If you stay in soil science you shall have your whole life to hate it." So I insisted on the course. After about 3 or 4 years of work in complex areas, he entered a graduate school. Along with soil science, he added economics as his minor. He had learned that good soil science coupled with poor economics can fail.

In my view each soil scientist should spend a few weeks each year, interviewing or working with our "customers" in the field to see their problems. I should include foresters, farmers, horticulturists, engineers, and town-and-country planners. I regret that many soil scientists remain almost exclusively in the laboratory and office. Instead of real problems, some of them work mainly on "cooked up" problems. Yet such reports get published, and this reader can say only: "So what?"

Whether all soil scientists like it or not, our soils are mainly out of doors; and this is where they must be studied, except for samples of specific parts brought in for examination and study in the laboratory or greenhouse. To interpret the results, however, he must try to go back to the real soil again or use a detailed notebook if the soil is far away.

Some specialization is needed in soil science, but overspecialization can make the soil scientist less useful to his fellow citizens than he could be.

I recall a simple example of years ago. I received a draft report of the suitability of soils in a western area proposed for irrigation. The leader of the research unit sent it to me for comments. I suggested that they must have taken their samples from soil between the shrubs, not under them. They returned to the area and found that the soils under the shrubs were loaded with salts and so were the green leaves of the shrubs. Irrigation of these soils would have been a costly disaster. But it did not happen.

OTHER CULTURES

The humanities are also important in the curriculum and for reading in order to communicate with others, as C. P. Snow has brought out so well in his great book, *Two Cultures*. We need a mingling of both the natural and social sciences along with the humanities for all students, both in college and in their reading. I recognize that many great ideas have come from scientists, but so have many come from poets and novelists. Successful teachers of soil science work many of these relationships into their lectures.

To work with peopie our students need some understanding of three great sets of relationships: 1) among things—the field of science, 2) between man and things—the field or art, including the industrial arts, and 3) among people—the fields of justice and morals.

Both small and large cultural systems have different views of these relationships. At first, however, they may seem more contrasting than they do later as we get to know the people and they us.

Soil scientists can do a very great deal to help people. Actually the world has soils enough to more than double the total area of rewarding farming. A large part of the world's population needs both more food and more good jobs. I should like to see American soil scientists able to do even more than they have.

I hope that more of our soil scientists take part in assistance to the less developed countries and help peasant farmers get more for their labor. We must continually recall that what they and we can do depends on the availability of transport and local services as well as on the technical assistance itself.

The soil scientist who is to be successful in a different culture should learn quite a bit about that culture in advance. In other words, he needs to be a good operating cultural anthropologist. Some of the customs may need to be changed to apply soil science and to develop good soil management systems, but he keeps suggestions for change to the very minimum, at least at first.

The traveller who does not understand—perhaps appreciate is a better word—the local religion, customs, and taboos can unknowingly insult the people and fail to get their confidence. But I do not want to exaggerate this possibility. It will not happen with a bit of reading in advance and with courtesy. I know.

Each potential American soil scientist can get a good education if he wants it, and it need not be narrow or grossly overspecialized. But to get it he must be curious, a wide reader, and anxious to be of service to his countrymen who need to select soils for their purposes and to manage or manipulate them successfully.

US Consortium of Soil Science Associations. Careers. Education. Education. Online Classroom Subscription.Â Degree programs (both on-campus and via distance education) may be viewed at the Career Center. no. Purchase A Subscription. The UWâ€"Madison Department of Soil Science is one of the oldest, largest, and most prominent soil science departments in the United States. It is globally renowned for its excellence in soil research and education. The department's mission is to provide instruction, research, and extension leadership in soil chemistry, physics, biology, and pedology to economic and sustainable land use. Programs are designed to improve basic understanding and practical management of soil resources in natural, agricultural, and urban ecosystems, and to serve local, state, national, and global interests.Â Three of only four soil scientists appointed to the National Academy of Sciences are from the UWâ€"Madison Department of Soil Science. Soil Science is a relatively broad discipline so I will try to give some context about what we do and the type of data with which we usually deal. Soil in the field and the laboratory. Soil is a complex body which can be described in many ways depending on if you are interested in its physical, chemical and/or biological properties, its location in the landscape, its interaction with the rest of the biosphere, etc.Â Each of those layers have different characteristics and, as soil scientists, we are interested in describing them as thoroughly as possible. A typical description usually includes attributes that are observable in the field (coordinates, layer thickness, colour, etc.) and information that we get after processing samples in the laboratory (pH, particles size, nutrients content, etc.). As a soil scientist, you'll need to: apply knowledge of soil science, including the fundamentals of the subject, such as the biological, chemical and physical properties of soils, and their spatial and temporal variability across the landscape. carry out field work, including the collection of soil samples from a range of environments. produce maps of soil types and their distribution.