Basic Life Science Prerequisites in Agriculture

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Abstract

Concern over the adequacy of prerequisites and the extent to which faculty structure courses to require satisfaction of prerequisites motivated a survey of academic administrators in agriculture to identify the scope of these problems. Land Grant institutions, including the 1890 institutions, and selected non-land grant institutions comprised the survey group. Survey responses suggest excessive variation among prerequisite courses, strongly descriptive production courses that fail to require quantitative skills, and faculty failure to enforce prerequisites in advising and teaching. Evaluation of curricula could reduce the number of required courses, increase student preparation, and allow greater flexibility for individual students.

Introduction

Many forces suggest changes in agricultural curriculum: the "information explosion," the requirements of prospective employers, and tradition. The basic goal remains focused on effectively and efficiently meeting the educational needs of our students.

At times our efforts yield an unbalanced product favoring technology over principles. Curricula seem to stress mastery of technical material at the expense of application of basic theory and principles. The opposite extreme stresses the basic sciences with inadequate efforts to forge practical applications.

Although not formally stated, curricula in agriculture have evolved under a philosophy that stresses the development of problem solving skills. Recently, partially in response to the information/technology explosion, many curricula seem to have lost this focus. We find curricula fail to build on basic, prerequisite material.

This withdrawal from building on principles appears in a variety of upper division (junior/senior level) courses: genetics, in which students fail to integrate basic biology with nuclear behavior and simple concepts of mathematics and statistics with biological variation; production/management courses in which students fail to integrate basic plant biology with forage management or chemistry with soil fertility or pesticide technology.

Our observations reveal two related basic issues: the adequacy of prerequisites and the extent to which faculty structure courses to require satisfaction of prerequisites.

Adequacy comprises at least three elements: scope, depth, and orientation of subject matter, including the intangible quality of teaching. Evaluation of these elements is at best, difficult. Student performance and feedback are reasonable criteria, but evaluation in this manner becomes confounded with the method of evaluation. Course syllabi and exams suggest the type and level of subject matter offered in the various courses.

Evaluating the adequacy of the prerequisites is difficult because basic science prerequisite courses frequently are administered and taught by departments outside agriculture. Adequacy becomes a complex question involving the scope and rigor of subject matter as well as the manner in which material is presented. The fact that frequently wide options exist in required prerequisite subject matter further complicates the matter, e.g. the choice of organic or biochemistry. Self-examination reveals that advanced courses are often taught at the "lowest common denominator" of prerequisites.

The extent to which satisfaction of prerequisites is required should be evaluated and enforced by the individual faculty member. However, enforcing prerequisites is linked to another "practical" problem. Low enrollment limits offering advanced courses. Prerequisites are ignored to bolster enrollment and faculty contend with students having diverse preparation. Pretests to determine the level of preparation provide a guide to the minimum preparation of students, but do not solve the basic problem.

Faculty identify weaknesses and try to review critical material to assist students. Although the willingness to offer such assistance is applauded, unfortunately the ultimate value may be to weaken a class. Rarely is adequate time available to TEACH the required prerequisite material without diluting the designated course material. A classic example of this occurs with plant breeding classes with a prerequisite of genetics and instructors who offer to cover the "essentials" for students who have not taken the prerequisite course.

Self-examination, peer evaluation of courses, and student feedback all will contribute to determine the relative emphasis placed on the application of prerequisite subject matter

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and the concurrent development of problem solving skills. Problems identified:

(1) For many courses prerequisites were inadequate and far too diverse to provide a solid foundation for developing problem solving skills that the future will demand of our graduates.
(2) We fail to enforce satisfaction of prerequisites and that this in fact reflects an uncertainty as to what constitutes an appropriate prerequisite.
(3) Frequently, in the face of diverse students or variable prerequisites, we fail to build on and use the required, prerequisite material. In some instances, we found no real, academic justification for prerequisites. We believe these problems are widely spread in agricultural curricula. To evaluate our position we recently completed a survey of academic administrators in agronomy and in colleges of agriculture.

Survey Structure and Scope

The survey included two groups of educational administrators: heads or chairs of departments of agronomy, plant science, crop science and soils and college level directors of academic programs in agriculture. The survey included a total of 58 college level administrators and 54 departmental administrators representing a total of 73 institutions. Most institutions were represented by both a departmental and college level administrator.

The survey included institutions from throughout the United States that awarded at least the bachelors degree. The initial population comprised the Land Grant institutions including the 1890 institutions, as listed in the 1993-1994 Directory of Professional Workers in State Agricultural Experiment Stations and Other Cooperating State Institutions. This list was expanded to include several non-land grant institutions: Cal Poly State University (San Luis Obispo) and Fresno State University in California and several representatives of the University of Wisconsin system. This relatively small group represented institutions with greater undergraduate teaching emphasis than graduate/research emphasis.

The survey instrument comprised a one sided single sheet designed so that it could be folded and returned to us by mail. The document was addressed and postage prepaid to encourage participation. A single mailing was made with no reminders or follow up instruments. Responses could not be traced to a specific institution; differences in the first two questions allowed separation between college and departmental administrators. Mailings were made in March 1994 and responses returned throughout the Spring and early Summer, 1994. Table 1 illustrates both questionnaires. Except for the first two questions responses were simple yes/no expressions of opinion.

To supplement and clarify the survey, we also reviewed course descriptions and agronomy curricula as they are described in the most current, official university catalogs or course bulletins or announcements. We limited this review to 15 institutions, each of which was also included in the survey (Table 2). This review focused on four specific points: whether the institution offered several options in the curriculum and if so whether the options utilized a common core of departmental (major) courses, whether the institution offered more than one introductory freshman chemistry sequence as indicated by choices in the agronomy curricula, whether students taking the same production courses had options in required advanced science, generally chemistry, and what curricula, if any, required calculus.

Table 1. Summary of survey instruments mailed to college and departmental administrators with differences between the versions to the two groups illustrated.

1. My opinion is based on general familiarity with agricultural production curricula in my college (#1 College Administrators).

1. My opinion is based on teaching agronomy classes and contact with faculty teaching agronomy (#1 Department administrators).

2. My opinion is based on specific examples from curricula in my College (#2 College Administrators).

2. My opinion is based on specific examples from curricula in agronomy (2# Department Administrators).

3. Agricultural production curricula in my college (version for College Administrators, for Department Administrators "Agronomy curricula in my department") require all students to satisfy prerequisites in the following basic sciences:

	yes	no
1. chemistry		
2. biochemistry		
3. organic chemistry		
4. physics		
5. calculus		
6. other math		
7. statistics		
8. genetics		
9. anatomy/physiology		
10. other		

4. In my opinion, courses in the traditional production crop and livestock (version for college administrators, Department Administrators "in the traditional crop and soils") curricula fail to build on prerequisite basic sciences.

5. The greatest deficiency appears to be in the _____ curricula.

OTHER COMMENTS OR OBSERVATIONS:

Survey Results and Discussion

Of the 112 total surveys distributed, nearly 68% (74) were returned. This included 42 of 58 college administrators (72%) and 34 of 54 department administrators (63%). For a mail survey without any follow-up or reminders, this response rate is high and within the limits of the questions should yield valid data. The high rate also seems to reflect at least interest in the questions posed, if not active concern.

Both college and department administrators nearly unanimously based their opinions on familiarity with college curricula or on specific examples through teaching agronomy courses. The results apparently reflect something more than a vague feeling.

In the third, multi part question which addressed required subject courses, the patterns of responses between the college and department administrators were very similar and reflected several basic patterns. Assuming "chemistry" to be general, introductory chemistry, all respondents indicate this as a requirement. Both groups revealed an approximately even split for required biochemistry, but not all respondents in either group addressed this question (only 24 of 44 college and 31 of 34 department responses). Fewer responses concerning organic chemistry were given, but the pattern was more consistent than with biochemistry. Of the 32 college responses, 25 indicated that biochemistry was required, and 24 of the 29 departmental responses also indicated such a requirement. Apparently a general tendency exists to require organic chemistry and not biochemistry. The data did not reveal whether institutions required organic chemistry but not biochemistry. Biology was unanimously a requirment. Clearly a general need for background in the life sciences is recognized in agricultural production curricula.

The physics requirement varied. Seventeen of the 29 college responses revealed a physics requirement, and 24 of 31 departmental requirements also revealed a physics requirement. The higher proportion in departments could reflect a specific, departmental prerequisite for soil physics and/or subsequent classes in irrigation for which physics is a prerequisite. The college response apparently reflects a broader spectrum of curricula of which some find no need for a physics requirement.

Table 2. Institutions from which agronomy curricula were reviewed to determine more details regarding the nature of required math and science courses.

Reviews based on 1993-94 institutional catalogs or comparable publications.

Auburn University
Colorado State University
Cornell University
Kansas State University
Louisiana State University
Mississippi State University
Montana State University
Rutgers
South Dakota State University
University of Florida
University of Illinois
University of Kentucky
University of Maryland
University of Puerto Rico
University of Wisconsin, River Falls

Only one-third of the college-level responses indicated required calculus (9 of 27 responses). In agronomy, although not all departments responded, 17 of 26 revealed calculus as a requirement. Apparently the "hard sciences" tend not to be required in some agricultural production curricula, but in agronomy, a greater tendency to require them seems to exist. The data suggest that other math is required. About two-thirds of the college and department responses revealed a statistics requirement. In general, college responses revealed a genetics requirement more than departmental requirements; however, this does not reflect a specific genetics prerequisite for plant or animal breeding courses.

About two-thirds of the college respondents indicated an anatomy or physiology requirement, and about 80% of the responding departments indicated this requirement. This question, on review, yielded little information. Differences at the college level between animal and plant science curricula, differences in prerequisite biology and chemistry courses, and differences in advanced production courses in which such concepts might be introduced all confounded interpretation of this question.

The final portion of this question revealed diverse opinions with a majority of respondents commenting. The need ranged from developing business skills, communications skills, and computer competencies to adding exposure to basic sciences (such as geology), environmental science, ecology, nutrition (human and animal), marketing, and multi cultural awareness and global issues. This latter group seems to reflect in part expanding career opportunities plus greater depth in general education requirements.

Thirty-three college administrators and 28 department administrators replied to the "keystone" question (#4) on whether curricula built on prerequisite sciences. Of the college administrators, one-third, 12 of 33, indicated that curricula failed to build on prerequisite sciences. A lower proportion of department administrators indicated that problem, 25%, seven of 28. Two facts suggest that these results might be misleading.

First, for both groups of respondents, over half commented on problems with prerequisites, regardless of the answer to the specific question. This clearly suggests a significant concern, if not a problem. Second, several respondents indicated that the question was unclear. They were uncertain whether "yes" indicated a failure or no failure to build on prerequisites. The intent was that "yes" indicated a failure. Considering the comments more than the numeric response, the survey results point to a significant problem. From the comments, the major weaknesses seem to be associated with applications of chemistry and mathematics in production courses.

The final question yielded a split between college administrators and department administrators. The former group noted specific curricula and the latter stressed specific types of skills.

Considering the skills, department administrators reported weaknesses in such skill areas as "clarity of thinking (logic) and writing," in the failure to have an orderly sequence of courses "up the curricular ladder," failure to "integrate basic sciences and other prerequisites, including humanities and social sciences, into courses," and failure to recognize competency as the issue with "too many prerequisites and not enough pretests to determine competencies." Three themes emerged from these comments: (1) excessive variation among prerequisite courses, (2) the fact that too many production courses remain strongly descriptive and fail to require quantitative skills, and (3) faculty failure to enforce prerequisites in advising and in teaching. Too many advisors allow students to register for courses for which they do not have specified prerequisites, and too frequently as a result, courses are taught to the lowest common denominator.

The comments from the college administrators appeared to be "institution specific." Several may have general interest. The greatest problem appears in curricula that are broad or general in nature. More of a problem exists in "production" curricula (animal science, agronomy, horticulture) than in the nonproduction curricula. Failure to build on prerequisites is not unique to agriculture, but it is a problem throughout higher education.

The review of catalog listings tends to confirm the nature of the problem. Based only on patterns of requirements apparent in agronomy curricula several facts emerge. Most institutions offer more than one option under the agronomy curriculum or major. Within an institution, all options share certain agronomy courses in common, but the options frequently have different requirements in basic sciences. This leads directly to the problem of instructors facing students with diverse preparations. The greatest diversity is in chemistry. Only two of the institutions offered more than one freshman chemistry sequence. Several offered a combination course in organic and biochemistry following the freshman sequence. Over half of the institutions allowed students the option of either organic or biochemistry following completion of the common freshman course. Curricula in soils were most consistent in requiring physics and calculus, but within this area some diversity existed within institutions regarding the nature of the required physics. Clearly, part of the problem with prerequisites stems from courses available outside of the major, and therefore not under the basic control of the department utilizing them as prerequisites.

Conclusions

The response rate suggests real interest in the issues raised, regardless of the opinion of the respondents. Apparently the short, simple instrument and return mailing convenience successfully encouraged participation.

Little variation appears regarding requirements of basic chemistry and biology. A significant split exists with respect to more advanced chemistry - biochemistry or organic chemistry. Curricula vary as to which if either is required, and this can lead to difficulties in advanced courses.

Calculus and physics requirements appear more in agronomy curricula than in agricultural production curricula in general, but this does not mean that these curricula build on these basic sciences. Statistics appears to be an important subject in many curricula, but the course content is not clear. More specific information is needed.

The general issue of building from basic science prerequisites represents the point of greatest interest. The fact that many respondents commented suggests that this is an ongoing concern to which attention should be given.

We suggest a serious evaluation of the principles on which subject matter is based and the development of precise behavioral objectives to assist the faculty in determining what is required and whether students are mastering essential subject matter. We also suggest that the content of introductory and sequential science courses be reviewed with the goal of agricultural students enrolling in the same basic science core courses as other students. This should eliminate duplication of courses and should allow all students greater freedom of transferring among curricula. It also should allow the faculty to depend on a specified level of preparation from prerequisite courses. A significant effort in this area could ultimately reduce the number of required courses, increase the basic preparation of our students, and allow greater flexibility of individual student programs.

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