An Alternative Approach To Teaching Laboratory

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Abstract

With the varied academic backgrounds of students enrolled in undergraduate courses in plant physiology it is often not possible to meet their educational needs and motivate them with conventional laboratory exercises using the "cookbook" approach. Course changes made in the past year are helping stimulate and motivate students to a deeper study and understanding of plant physiology. The approach being taken offers a "project oriented" laboratory in which students design, conduct, evaluate, and present oral and written reports on their results.

This approach has been implemented in two courses through the purchase of some and the design and construction of other instructional modules and equipment. An increased motivation to greater in-depth study of plant physiology was depicted by the extent of student involvement in three sequential courses.

This approach in teaching the laboratory has the advantage over conventional methods in that the student works in an area of his interest, utilizes time more efficiently, maximizes utilization of equipment, and experiences a better opportunity for individualization of instruction. Student projects can be of scientific merit and, if monitored properly, are of a publishable nature. Having experienced these advantages, we see a need to expand the program so more students may benefit.

As an outgrowth of an experimental course "Creativity and Innovation in Plant Physiology Instruction" (Hale, Moore and Orcutt, 1976), suggestions made by student participants are now being implemented in two plant physiology laboratory courses in an attempt to motivate students to a deeper understanding and appreciation of plant physiology.

Students participating in undergraduate courses in plant physiology come from a variety of backgrounds and have different levels of knowledge, skills, and aptitudes. Plant physiology courses are often required for undergraduate students majoring in Agronomy, Horticulture, Forestry, and Agricultural Engineering. Occasionally, students majoring in Botany, Biochemistry, and Animal Science also participate. Therefore, the proper learning environment requires a flexible program of instruction that meets specific and general needs. Devoting attention to individualizing instruction, creating opportunities for exploration, and updating facilities and the learning environment provide new motivation and incentive to learn which will ultimately lead to a greater feeling of accomplishment. Current and proposed approaches to teaching physiology courses are presented so that others may benefit from our efforts to increase individualization and flexibility in instruction.

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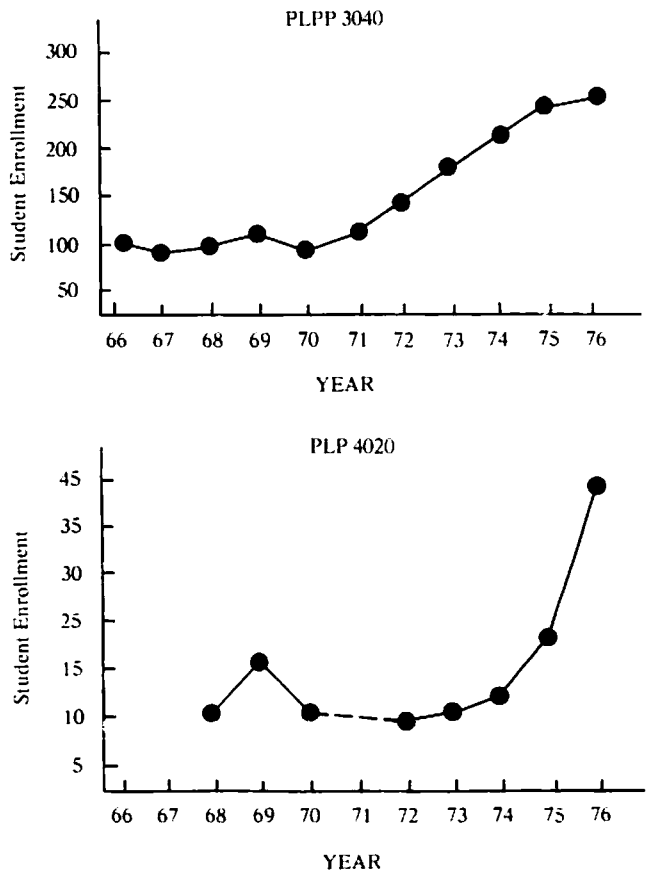
Present Course Descriptions

Two courses offered by the Department of Plant Pathology and Physiology (Plant Physiology 3040 and Plant Growth Regulation 4020) provide the basic plant physiology background needed by undergraduate students. Both courses have three hours of lecture and three hours of laboratory per week for a total of four credits each quarter. Plant Physiology 3040 and Plant Growth Regulation 4020 have average annual enrollments of 230 and 35 students, respectively.

Figure 1 illustrates the enrollment in the two courses for the past ten years. A total of 1600 students have participated in the two courses during that time, with about 40 percent of that total enrollment occurring in the past three years. The Department of Plant Pathology and Physiology is in the College of Agriculture and Life Sciences which had the third largest increase in enrollment of any Land Grant University in the United States in 1975.

The lectures provide students with basic information concerning plant structure and function, mineral

Figure 1. Comparison of Enrollments in Plant Physiology Courses for the Past 11 Years.



nutrition, water relations, photosynthesis, metabolism, growth, development, and utilization of synthetic growth regulators for agricultural purposes. Although the courses deal primarily with basic principles, attempts are made to relate established principles to applied uses. The laboratory is required for both courses. Five laboratory sections of 40 students each are offered in 3040 and one section in 4020. Students in the past have been required to work in large groups and conduct pre-designed experiments illustrating some physiological principle.

Course Deficiencies

The basic deficiency in the courses as they now exist is the "cookbook" approach of exercises in the laboratory portion of the courses. This has been and continues to be a common approach to teaching laboratory in many scientific fields and to a certain extent has its useful attributes. But we feel it has more problems than merits for the following reasons: (A) The motivation and creativity of students is stifled. (B) The experimentation lacks sophistication and does not reflect up-to-date methodologies currently used in the discipline. (C) There are logistics problems related to equipment availability and individual student participation in experiments. (D) Flexibility is lacking which would allow students to pursue and develop their own interests, and (E) Equipment and physical facilities are not efficiently utilized. B and C are particularly significant when large numbers of students necessitate pre-designed experiments commensurate with limited instructional funds and are thus of little value in representing the tools and methodologies currently being used in the science.

Improvement Plan

The basic improvement plan has and will incorporate the following:

A Eliminate, where possible, the pre-designed laboratory and replace it with the "project oriented" laboratory in which students design, conduct, evaluate, and present an oral and written presentation of an original project of their choosing. To familiarize students with the available equipment and its use, they are given a tour of the department's facilities and each piece of available equipment is demonstrated. At the same time, several experiments are described that could be conducted using the equipment. This approach is most realistic in small enrollment courses because there are a limited number of individual projects and sufficient equipment and facilities available.

B It is practically impossible to use the "project oriented" approach in large enrollment sections (Plant Physiology 3040). An alternative has been provided by offering Plant Physiology 3040 more frequently (fall and spring) and creating an "honors" section in the fall. The fall offering will use the currently pre-designed laboratory approach, but experiments will be supplemented with more current instrumentation and methodologies which relate to the pre-designed exercise. Student volunteers will participate in the more advanced experiments and demonstrate the results to the rest of the class.

The "honors" section has provided an added degree of flexibility in that small numbers of students have the opportunity for more individualized instruction and participate in the project oriented lab. The requirement for participation in the honors section is a grade point average of 2.5 out of 4.0 and is offered as a regular course listing with a maximum enrollment of 20 students.

Offering Plant Physiology 3040 in the spring will reduce the enrollment pressure experienced in the fall and allow for implementation of the project oriented approach in laboratory.

C We have found the "project oriented" laboratory to be a great motivating factor in stimulating students to continue their studies in plant physiology. Most institutions offer independent study and undergraduate research, but too often these courses are considered a burden to faculty and are not often advertised or used to help students develop in areas of their interest. Therefore, we have encouraged those students who wish to further their studies to participate in undergraduate research or independent study.

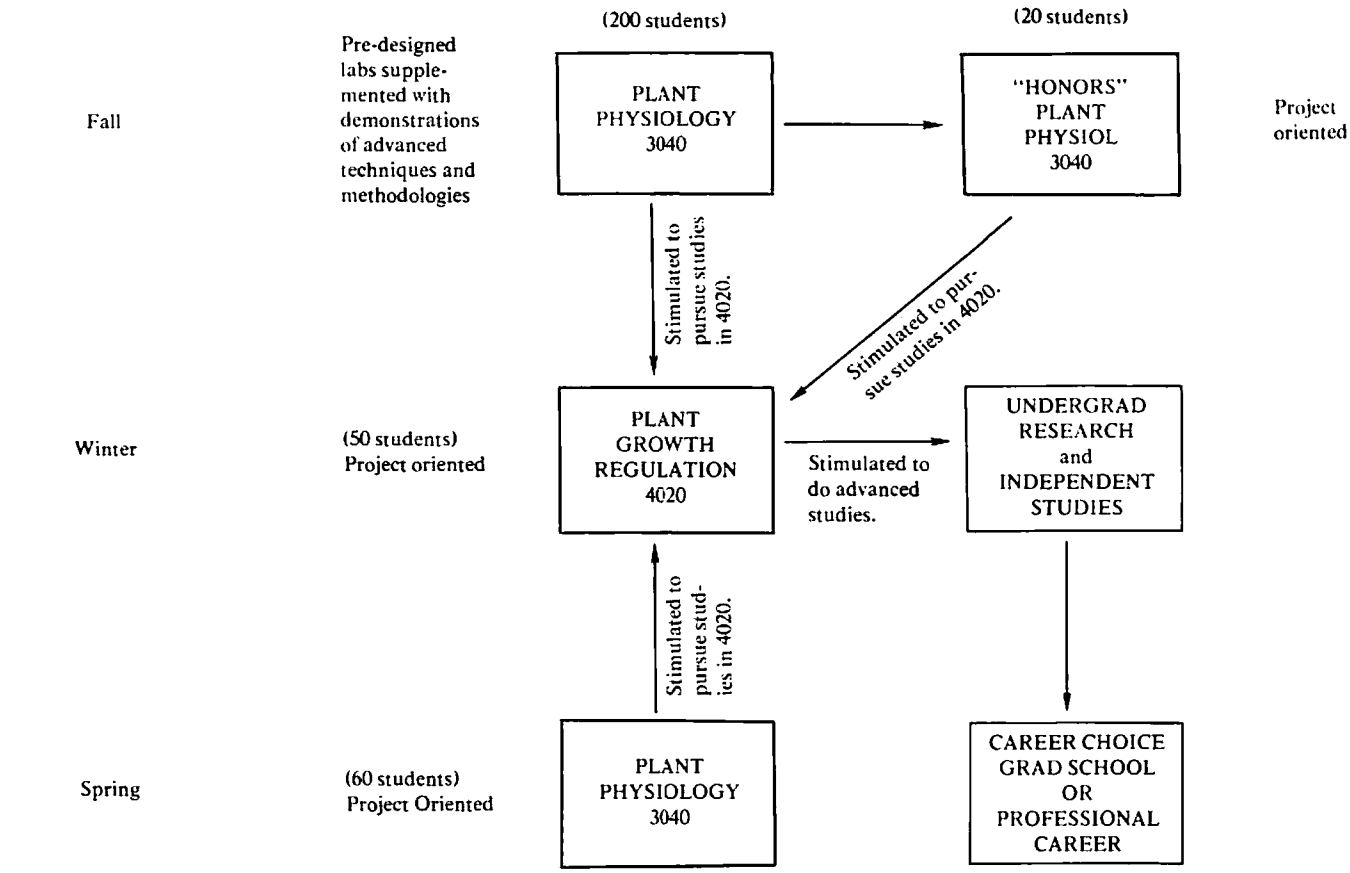
We believe this system lends itself to a more individualized approach to teaching which then helps the student unmask the often hidden interests which have not been allowed to mature because of the rigidity of the system of instruction. This in turn is a great injustice to the development of any discipline and society as a whole. We feel that proper implementation of project oriented labs will better motivate students, provide for more individualized instruction, make better use of available equipment and facilities, help students develop and recognize their interests, and be more flexible in relation to the students' time. Also, the results of their individual efforts will have scientific merit and, if pursued adequately, could be published.

De-Motivating Factors

Efficient equipment utilization is probably one of the major limiting factors associated with conducting an effective laboratory. This is particularly true in large enrollment laboratories in which a limited supply of expensive equipment necessitates that groups of students work together. This is one of the most de-motivating factors associated with laboratory courses, for when students cannot actually do the laboratory experiment individually, interest and motivation are lost. In the project oriented laboratory, students are not required to attend a formal laboratory session although a time slot is reserved to discuss problems, give progress reports, and present final project reports. This flexibility, then, reduces the pressure on limited facilities and equipment because it is not necessary to invest in a large number of individual pieces of equipment, and the need for large laboratories to accommodate high enrollment classes is reduced.

An additional element of flexibility has been observed using the project oriented laboratory approach. Many

Figure 2. A System of Instruction Based on Project Oriented Laboratories.



students have available to them resources for conducting experiments that normally would not be available in a structured laboratory situation. These resources are often available in the students' home department, and students are encouraged to make use of those facilities only if using them does not impose on other projects. As a result, efficiency of equipment utilization is expanded and often times more convenient to the student and, more important, the student gets to use the equipment.

The other aspect of de-motivation in laboratories is the pre-designed exercise. In many instances the outcome of such exercises can be anticipated by the student. As a result the student "dry labs" the exercise and gains nothing from it. At this point, motivation is at its lowest. Allowing students to design, conduct, and evaluate the results of an experiment that they are interested in conducting puts experimentation back into the laboratory along with the element of discovering the unknown.

One of the major problems encountered particularly in undergraduate courses is orienting students as to the kinds of experiments they can conduct. This is especially critical if courses are conducted on a quarter system in which time is short and growing of plants is involved. Therefore, students have to make early decisions on the kind of project they want to conduct. As indicated earlier, a tour of our facility and an introduction to the kinds of equipment and types of experiments for which the equipment can be used is demonstrated the first week of class. Students are encouraged to develop their own projects, but a suggested list of experiments is distributed. Another problem encountered is anticipation of the kinds of experiments students will want to conduct so that adequate supplies can be on hand. Finally, the demands on staff time are greater using this approach. However, the benefits in terms of both staff and student interest make the "project oriented" laboratory productive, stimulating, and otherwise worthwhile.

Progress Made To Date

We implemented this program to a limited extent during the 1976-77 academic year and feel it has great potential not only in motivating students but also developing scientists in an area of increasing need. Eight students enrolled in the honors section of Plant Physiology 3040. Of the eight students, four elected to pursue their interests further in Plant Growth Regulation 4020. Of those four students, three have requested to pursue additional studies in undergraduate research. The progression of students through three courses in which the project oriented approach was used illustrates the utility and motivating force of such a system. Figure 2 illustrates the possible course relationships relative to student participation in project oriented studies.

The following list of projects completed by students in the project oriented system indicates the caliber and diversity of experiments conducted by students:

(1) The Effects of X-Irradiation on Squash Seeds and Subsequent Sterol Metabolism in Seedlings.
(2) The Effect of S-Gibberellic Acid 10 percent and 3-Indole Butryric Acid on Germination, Growth, and Subsequent Sensitivity to Ozone on Sweet Corn.
(3) An Investigation of the Effect of Cycocel on Sunflower: Analysis for Potassium and Calcium Content.
(4) The Effects of B-Napthoxyacetic Acid on Fruit Set of Greenhouse Grown Tomatoes.
(5) The utilization of Benzimidazole as a Protectant in Radish Plants to Various Levels of Ozone.
(6) The Effects of Cycocel on Photosynthesis and Respiration of Elodea and Chlorella.
(7) Concentration Effects of Cycocel and Stage of Development in Relation to Sterol Synthesis in Sunflower.

The following objectives are yet to be accomplished: (1) Incorporation of equipment into the physiology sections in which pre-designed experimental approaches are used. (2) Incorporation of the project oriented approach into the spring quarter offering of Plant Physiology 3040. (3) Evaluate the relative effectiveness of project oriented labs and pre-designed labs using student evaluations of the courses, grade distribution in the respective courses, and personal responses from students.

References

1. Hale, M.G., L.D. Moore, and D.M. Orcutt. 1975. Preparing Graduate Students for Instructional Roles. *NACTA Jour.* 19:4, 19-22.

INTERNATIONAL AGRICULTURE

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NACTA's Interest and Experience

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One of the first goals of the NACTA International Affairs Committee was to determine the extent of interest and experience of NACTA members in International Agricultural service. A questionnaire was developed and sent to all 450 active NACTA members in February, 1976. Responses were received from 140 members which represented 31 percent of the active NACTA membership. The following data represent a summary of the interest and experiences of those who responded. It may or may not be a reliable statistical representation of the total NACTA membership.

The data suggest a broad range of experience by NACTA members in International Agriculture. Sixty-three members indicated foreign service in 64 countries. There was no major concentration in any one country or any one continent. Instead, NACTA members indicated service in every continent of the world except the Arctic and Anarctic. Twelve members indicated foreign service in India, seven in Columbia, six each in Nigeria and Brazil, and five in Great Britian. Less than five members served in all other countries reported. Table 1 summarizes NACTA membership experience by continents.

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TABLE 1. NACTA Membership Experience in International Agriculture by Continents

Continent	Number of Members
South and Central America	15
Africa	16
Europe	13
Asia	18
Australia	2
TOTAL	64

NACTA members were asked what major responsibility they had during their foreign service. A wide variety of answers was given. An attempt was made to summarize the responses into the following catagories: teaching, research and development, administration, consultant, and extension. Some members reported only one type of service whereas others reported three or more. Table 2 shows extent of service in each catagory.

TABLE 2. Type of Foreign Service by NACTA Membership

Type of Service	Number of Members
Teaching	71
Administrative	47
Research and Development	43
Consulting	15
Extension	9
Total	185

Twenty-seven different agencies were listed as employers of NACTA members in International Agriculture. The major agency was the U.S. Government through the Agency for International Development (AID), the Peace Corp, and the Fulbright Program. Other government agencies listed included the State Department and the National Science Foundation.