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THE OLD PROGRAM AND ASSOCIATED DIFFICULTIES

Until recently, Marquette's undergraduate curriculum consisted of a two-semester, general biology course offered at the freshman level and upper division core courses in cell biology, environmental biology, genetics, and developmental biology. Each of these courses had an associated laboratory. The introductory course was taken by majors as well as nonmajors, and each major took all the core courses as well as several biology electives.

We experienced several difficulties and inadequacies with this rather standard curriculum. The enrollment in the General Biology course ranged from 750-800 students and the core course enrollments were 100-125. Although meaningful instructional experiences could be provided for such large numbers of students in a lecture situation, the difficulties associated with simply ensuring adequate logistic support for the laboratories had become formidable, and we could see that they would grow worse with time. Of more importance than logistic support, however, was the problem of ensuring that each student was provided with maximum learning opportunities.

Careful examination of our program revealed that laboratory time was often used primarily for the illustration of selected principles previously introduced in the lecture. Even if this form of laboratory usage could be entirely justified, time limitations were such that, despite considerable skill in design, a given student could not be expected to gain more than a superficial insight into the half-dozen or so phenomena which he could personally investigate. It was our opinion that this facet of undergraduate laboratory use could be effectively replaced, with considerable saving in time, by more imaginative classroom techniques.

The laboratory was also being used to teach experimental methodology. However, time limitations often resulted in programs centering around the utilization of a few readily mastered and relatively unsophisticated procedures which actually did not indicate either the capabilities or the limitations of contemporary research methods. Furthermore, approaches of this and the foregoing kind have in some instances led to repetition of subject

matter in different courses; a situation difficult to justify and expensive to sustain.

THE NEW PROGRAM AND ASSOCIATED BENEFITS

After considerable deliberation and soul searching, we finally came to the conclusion that the laboratory could best be exploited for the purposes of developing the critical capacity of the undergraduate; to provide scope for his creative development in the handling of real questions; and to increase his appreciation for the operation of the research mechanisms which provide the basis for present-day biological thought. The close student-professor interaction which was potentially possible in the laboratory suggested that it was uniquely suited for this purpose. We realized, of course, that the employment of the laboratory in this role is compatible with neither large sections nor the highly structured exercises typical of many of the present undergraduate laboratory programs. It was quite obvious that our major task was to devise a program which would make maximum use of our faculty, financial, and physical resources.

Uncoupling Lecture and Laboratory

As an initial step, we decided that we would uncouple lectures and laboratories. Under this system, the units of the suggested core lecture program would continue to perform what had been their original function — that of presenting to the undergraduate, in sequence, the fundamental themes of modern biology. We felt that the imaginative use of more illustrative classroom techniques could partially compensate for the omission of the traditional companion laboratory. The potential of the laboratory could then be directed toward the exploration of the rationale and method of the investigative process, and to the development of the creative and critical abilities of the student.

Reduction in the Laboratory Requirement

Concomitant with the design to uncouple laboratories from lectures and to offer these as separate courses was the decision to reduce the number of such laboratory courses. We felt that our biology majors could best be served by a few investigative-type laboratory experiences rather than requiring an uncoupled laboratory course for every lecture course taken. The decision as to which laboratory courses were to be offered was one of the most difficult decisions to be made. After careful analysis of the strengths of the faculty and needs of our particular group of biology majors, we decided to offer only four uncoupled laboratory courses at the upper division level. Accordingly, we recommended laboratory courses oriented toward Molecular, Cellular, Regulatory, and Developmental Biology, these being the major areas of research competence of our faculty. Each course was designed to have two 3-hour meetings per week, and to carry three semester hours of credit. The first two courses cover subcellular and cellular phenomena, whereas regulatory and developmental biology are directed toward organismic activities. Each undergraduate is required to complete one course from each group as a

formal requirement for his biology major. However, a student may take any of the others for elective credit toward his major.

The implementation of such a core laboratory curriculum had several immediate benefits with respect to the use of the department's physical, financial, and faculty resources. First of all, this meant an immediate reduction in the number of laboratory courses being offered by the department. Furthermore, we found that we could schedule laboratory courses so that they no longer had to compete for utilization of space with other courses taught in the same semester. This meant that students could set up their experiments and not have them disturbed by students from other classes scheduled to use the same laboratory facilities at some other time during the day or week. Furthermore, students could now have free access to the laboratory to conduct their experiments. The latter factor is an important and essential component of any investigative laboratory program. Needless to say, the task of scheduling courses became a considerably simplified task for the department. We also found that we could readily accommodate all of our undergraduate laboratory courses without resorting to evening or Saturday classes, without any further consideration of renovations, or without additions to our building to provide more instructional space. As a matter of fact, we were able to convert two of our small teaching laboratories into graduate student offices.

Separation of Teaching Responsibilities

Another important aspect of our decision to uncouple and reduce the number of laboratory courses was that we were now able to separate the teaching responsibilities of our faculty. In accordance with their personal preferences and competencies, specific faculty members were assigned to teach the core lecture and laboratory courses. No longer are faculty forced to split their efforts between the lecture and the laboratory, with the supervision of the laboratory often being delegated to a teaching assistant. In establishing faculty loads, the teaching of laboratory courses carries the same weight as that of lecture courses. Thus we now have direct faculty involvement in our laboratory program. Regardless of all other benefits that have accrued from this type of approach, we consider this to be one of the most salient features of our program.

Another important benefit of the decision to require our students to take only two of the four laboratory courses is the immediate reduction in the number of students taking a given core laboratory course. Where our coupled lecture-laboratory courses carried enrollments of 120-125, we now have manageable class sizes of 30-35. Furthermore, we rarely have to schedule more than two sections of a given core laboratory course whereas we normally had six to eight sections to accommodate the equivalent core lecture-laboratory course. The educational advantages of enrollments of this size need hardly be described to any faculty member who has had to handle large enrollments in a laboratory program. Furthermore, the financial savings which accrued to the department from such a program were applied to purchasing more sophisticated instructional equipment and for the wider variety of materials demanded of an investigative laboratory approach. The latter was accomplished without any additional funds being added to our

operating budget and yet we have a far more sophisticated and higher quality program than before.

The uncoupling of the laboratory and lecture and the development of a laboratory core was based upon a consideration of what the majors needed. It was our opinion that the primary purpose of the laboratory for the nonscience major should be that of illustrating the experimental method of science through an investigative approach rather than a superficial demonstration of known facts presented in the lecture. Having made this decision, we could see no obvious benefit accruing to the student from the extension of such a laboratory over two semesters. Accordingly, we reorganized our General Biology course into three one-semester courses: Biology 1, 2, and 3; the latter being the laboratory component of the introductory program. The laboratory course (Biology 3) has as its prerequisite Biology 2 which can be taken concurrently with, or subsequent to, that course. Finally, we also reasoned that the student majoring in biology would derive no great benefit from this introductory laboratory since he would be getting an intensive experience in the investigative laboratory approach in his upper division years. Consequently, we do not require that our biology majors take the General Biology (Biology 3) laboratory course although they are required to take the freshman lecture sequence (Biology 1 and 2).

It should be immediately obvious that a considerable saving of faculty and financial resources has derived from the implementation of this general biology program, resources which have been redeployed to the support of other undergraduate and graduate programs. First of all, there is the substantial saving in instructional laboratory space which was effected by such a program. With reduction of the freshman laboratory requirement from two semesters to one and the absolving of biology majors from this requirement, we immediately reduced the number of laboratory sections from 30-35 to 12-16 per semester. Furthermore, we were able to limit the enrollment per section to 20 students as opposed to an average of 24-28 under the previous arrangement. Instead of using four laboratories exclusively for our general biology course we were now able to accommodate these in only two laboratories, thereby freeing two classrooms for upper division and graduate laboratory usage. This move also enabled us to schedule our freshman laboratories at more reasonable hours during the day and has effectively removed any need to go to Saturday laboratory sessions. What had previously been an onerous logistic task of scheduling and handling large numbers of students has been reduced to an easily manageable job for the department. Furthermore, the substantial savings of departmental resources have enabled the department to strengthen its total curriculum while significantly improving the quality of its commitment to the nonscience major taking our freshman biology course.

Reduction in the number of freshman laboratory sections offered per semester also significantly reduced the number of teaching assistants assigned to this course. This enabled us to implement a series of discussion-review sessions to accompany our General Biology lecture program. Since we lecture to all 750-800 of our biology students at one time, we were desperately in need of providing some mechanism for these students to have open discussion on the material presented in lecture. We have used the teaching assistants freed by the reduction in laboratory sections to staff these discussion-review

sessions. In those institutions with smaller numbers of students taking General Biology, these teaching assistants can be used to upgrade undergraduate and graduate laboratory instruction.

For the biology major, we have substituted a new lab course entitled "Principles of Biological Investigation," which is normally taken in the first semester of the sophomore year and is a prerequisite for each of the uncoupled core laboratory courses. This course has been designed to give the background we have found to be essential for meaningful experience, and a satisfactory level of achievement in investigative laboratory courses. It consists of lectures and laboratory studies designed to provide basic instrumentation, technology, and principles of experimental design.

Centralized Equipment Facility

The cost of providing the equipment necessary to implement an investigative laboratory program is a major concern of many departments. This problem is compounded by the fact that equipment is usually assigned to specific laboratories and is consequently unavailable to other courses even though the equipment is not being used when needed in another laboratory. Furthermore, this practice frequently leads to an excessive duplication of equipment and an investment which is out of proportion to the variety of equipment available. For example, departments may have four or five laboratories, each equipped with a complete set of microscopes, and yet lack the funds to purchase a refrigerated centrifuge or UV spectrophotometer. Such an investment in microscopes may indeed be justified if they are all being used in each of the laboratories at the same time. This rarely proves to be the case. Careful examination of our own equipment utilization, even during peak laboratory periods, showed that we rarely found the same types of equipment, whether it be microscopes or colorimeters, being used at the same time.

Based on the facts described above, we decided to establish a central equipment facility where all readily moveable instructional equipment is stored when not needed for a particular laboratory experiment. Concomitantly, we set up a comprehensive card index on every piece of equipment owned by the department. This procedure gave us a complete inventory of all equipment owned by the department which not only proved to be an invaluable asset for insurance purposes but also permitted us to control the movement of all equipment in the building.

An immediate asset provided by this system was the discovery that our need to duplicate certain items of equipment such as microscopes, water baths, and colorimeters was eliminated. Savings proved to be substantial enough for us to justify the hiring of a full-time equipment supervisor in place of the part-time help which had been used to maintain and operate this facility. We quickly realized additional financial savings because such an individual soon became able to service and maintain most of our equipment. Constant equipment maintenance not only resulted in substantial savings to the department but also reduced the rate and extent of damage, thereby extending the life of the equipment. Finally, we achieved the satisfaction of having maximally functional equipment available to our students. The value

of the latter cannot be measured in dollars and cents. There is nothing more demoralizing to a student in the laboratory than to find his equipment inoperable. In some cases the student cannot proceed with an experiment because he must wait for the equipment to be sent off campus for repair or for a qualified serviceman to come to the department. This is not to say that we do not have to do this but the number of times that we must has been significantly reduced.

In addition to the hiring of an equipment supervisor from the savings realized from centralizing of equipment storage was the fact that we were able to purchase a wider variety of equipment and to coordinate our purchases more effectively. Rather than duplicating existing equipment, we are now able to purchase such major items as DU spectrophotometers, refrigerated centrifuges, fraction collectors, incubators, and freezers.

When we began to revise the instructional laboratory program at Marquette, we were not at all sure that it would be possible to replace our traditional program with an investigative one without either diluting the quality of our other offerings or pouring significantly greater human and financial resources into its operation. But in the process of working toward our stated goal — to develop an undergraduate program built around a core curriculum in which the laboratory offerings are of an investigative type — we have discovered that we have been able to provide greater flexibility for students, increase student-faculty contact, provide separate rooms for each laboratory, decrease the number of students in each laboratory, buy additional laboratory equipment, hire an equipment manager, and reduce the number of courses which each faculty member must teach. These benefits, in addition to those which students receive as a result of the investigative experience itself, have been possible even though we have a large number of students to accommodate and limited resources.