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KEAN & O'LEARY

OBSERVATIONS AND RECOMMENDATIONS CONCERNING CREATION OF A SARJANA (S_1) PROGRAM IN CHEMISTRY AT INSTITUT PERTANIAN BOGOR

Marion H. O'Leary

Elizabeth M. Kean

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INTRODUCTION

Institut Pertanian Bogor has committed itself to the establishment of a curriculum in chemistry at the Sarjana (S_1) level within the newly-created Faculty of Science and Mathematics. The proposed program is described in the document "Feasibility Study for the Establishment of a Faculty of Sciences and Mathematics at the Bogor Agricultural Institute*" (1980). This document outlines the rationale and objectives for establishment of the Chemistry Program. Also included are staffing needs, facilities needs, and the outline of a proposed curriculum. The program has been scheduled to admit its first students in 1984. At this point, the curriculum is still in the early planning stage.

As part of our visit to IPB, we were asked to consider the development of the curriculum and to make recommendations concerning its implementation. In order to learn about other Sarjana curricula in Indonesia, we visited chemistry departments at Gadjah Mada University (UGM), Bandung Institute of Technology (ITB), and the University of Indonesia (UI). We also talked extensively to staff at IPB. Thus, we have gained some information about chemical education in Indonesia. We hope that this knowledge, together with our knowledge of chemical education in the United States, may allow us to make useful suggestions concerning the Sarjana program in chemistry at IPB. However, we are by no means experts on the Indonesian or American educational systems, and others with a broader knowledge may wish to disagree with some of our recommendations.

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*We will refer to this document as "Feasibility Study".

Our objective in this document is to share experiences and observations concerning chemical education to make recommendations concerning the orderly development of the chemistry curriculum at IPB.

CHEMICAL EDUCATION AT OTHER INDONESIAN UNIVERSITIES

All three universities visited (UI, UGM, ITB) have S_1 programs in chemistry graduating 15-40 students per year. At this time, only ITB has an S_3 program, although an S_3 program is being developed at UGM.

The level of staff traning is generally high. UI currently has 25 staff, of whom half have received or are receiving foreign training. UGM currently has 24 staff. ITB has 35 staff, including 10 Ph.D.s. all ITB staff are required to obtain foreign training at some point.

The Sarjana curriculum contains a much larger amount of chemistry than does the comparable American curriculum. Roughly 100 credits out of 144 required for graduation are in chemistry (required courses and electives). American students take only 40-50 credits in chemistry prior to graduation. Most of these credits are in required courses; only about 20% of them are electives from within chemistry. This balance between required and elective chemistry courses is similar to that in American universities.

The length of Indonesian programs vary. Although the Ministry of Education requires at least 144 credits for the Sarjana degree, the chemistry program is nominally 4 years at UI, 5 years at UGM, and 4 1/2 years at ITB. Faculty at all three institutions reported that a large number of students fall behind and fail to complete the course of study on schedule. In fact, Ministry of Education

requirements regarding the maximum time allowed for the Sarjana degree (7 1/2 years total) constitute a serious problem for a number of students.

Course loads of Indonesian chemistry students seem heavy. Most students take at least 5 science and mathematics courses every semester, including two laboratory courses. Perhaps this load is related to the fact that many students fail to complete the curriculum on schedule.

The Ministry of Education requires that all Sarjana students do research and write a scripsi prior to graduation. Some programs provide for two semesters of research, and some for three. As in any research experience, it is important that flexibility be maintained. Some students will complete their research quickly, but others will require a long time because of problems with the experiments, time requires, personal problems, etc.

We note in passing that the full-credit system is going to have a significant impact on programs such as chemistry. It will permit the faculty to provide a more flexible program which is more appropriate to the needs of individual students. Efficient, highly-motivated students can increase their rate of progress through the curriculum. Other students will be able to extend their program by a semester or two in order to keep their workloads within tolerable limits.

We have not been able to evaluate in detail the content of the various courses offered at the various institutions. Thus, we are unable to compare the level of the various courses with the level of the corresponding American courses. However, we note that the textbooks used in Indonesia are often the same ones used in the US

(e.g. Morrison and Boyd in introductory organic chemistry; Daniels and Alberty in introductory physical chemistry); it is likely that the level of courses in the two countries is similar.

There is a general agreement among chemistry faculties that textbooks should be in Bahasa Indonesia, particularly at the lower levels. All institutions except UI have locally-prepared materials in Bahasa Indonesia for at least the first two years of the curriculum. At UI, all texts are in English, but first-year students are required to take an English course in which their chemistry text is one of the required reading books. However, there is currently a move towards Bahasa Indonesia texts at UI.

Sarjana graduates in chemistry will often be required to use English-language technical materials. In recognition of this fact, courses in the third year and beyond at ITB have primarily English-language materials.

GOALS

We assume that the goal of an S_1 program in chemistry at IPB is to train professional chemists who will work in industry, in government laboratories, in private research laboratories, and in agriculture. Two specific issues must be addressed:

1) Students should learn a basic body of chemical knowledge in each of the four areas of chemistry: organic, inorganic, analytical, and physical. Students should learn something about the relationship of this knowledge to problems in agriculture and the environment.

2) Students should learn a variety of laboratory skills, including preparation and manipulation of solutions, chemical analysis, chemical separations, preparation and purification of chemical compounds, use of scientific instruments, etc.

This second goal, in particular, requires advanced preparation because of the need to purchase chemicals, equipment, and supplies prior to the beginning of the program.

At this point we do not set specific goals with regard to enrollment and graduation in the program. Our recommendations are based on the assumption that only one section (class) in each advanced subject is taught each year. This means that up to 40 or 50 chemistry majors could be accommodated at the beginning of the second year of the Sarjana program. Thus, we might expect to have 10-20 graduates from the program each year.

STAFF BACKGROUND

Chemistry at the advanced S_1 level is a complex subject. It is difficult to understand and difficult to teach. The laboratory skills required are complex.

Most of the present chemistry staff at IPB received their primary training in a field other than chemistry. If they are to become effective members of the staff for the chemistry Sarjana program, they must be given an opportunity to broaden their knowledge of chemistry. It is important that all these people be included as the chemistry program is developed. Thus additional staff training must be a high priority.

Further development of the chemistry curriculum is not practical until the first part of this staff improvement process is completed.

Recommendation 1: Highest priority should be given to building a staff containing at least one staff member with a masters degree in each of the four areas of chemistry (organic, inorganic, analytical, and physical).

Recommendation 2: Further development of the chemistry program should be deferred until these four individuals have completed their training.

If these four staff members can begin their training during 1983, then they should return to IPB during 1985, and it should be possible to begin the program in 1986.

Planning a curriculum is a time-consuming process. Goals must be set; equipment and supplies must be obtained; courses must be designed; texts and other teaching materials must be obtained. We expect that the four staff members discussed above will be the leaders in this process. It is essential that they be given time, support, and recognition for this curriculum-development work.

Recommendation 3: These four faculty should be given relative freedom from other responsibilities to permit them to work on curriculum planning.

It is likely to take a year of planning by the Chemistry Department to develop the S_1 curriculum, even if recommendation 3 is followed. If recommendation 3 is not followed, substantially more than a year is likely to be required.

During this development period it may be useful to obtain additional support and cooperation from the University of Wisconsin team.

This initial group of four staff members with M.S. degrees will form the nucleus of the curriculum planning group. However, additional expertise at this level will be required before the program is fully operational. Therefore,

> Recommendation 4: At least four additional staff should be trained at the M.S. level (one in each of the four areas of Chemistry) within the first 3 years of operation of the program.

It will be noted that we have made no recommendations with regard to Ph.D. level training for chemistry staff. We believe that it is in the best interest of IPB to have a number of Ph.D. recipients on staff. This is consistent with the practice of other departments at IPB and chemistry departments at other Indonesian universities. However, this must be a longer term goal of the Department. It will not be possible to obtain a reasonable level of Ph.D. training prior to the start of the program. However, for the longer term, goals should be set both for Ph.D. level training and for M.S. level training of department staff. It is also important that training in chemistry be provided for staff members whose primary training was in other areas.

Recommendation 5: Within the first 8 years of operation of the curriculum, at least 50% of the chemistry staff should have training in chemistry at either the M.S. or Ph.D. level.

During the next 3 years, while the training of the first group of M.S. chemists is being completed, it is important that those chemistry staff who remain in Bogor have a chance to improve their chemical knowledge.

Recommendation 6: An inservice training program for chemistry staff should be instituted.

Several possible formats might be considered:

1) A chemistry professor from another institution might be invited to give a short course (2-6 hours per day for 1-4 weeks) on a particular chemical subject.

2) The chemistry staff might institute a weekly "seminar" program. All staff would be expected to read an article or a chapter from a book prior to the meeting. Staff members would take turns leading the discussion.

A variety of texts and other materials at the advanced undergraduate/beginning graduate level are available which could be used. Staff with expertise in particular areas could share their knowledge with other staff.

TOTAL STAFF SIZE

The present chemistry staff appear to be fully occupied with the teaching of service courses. A large number of new courses are going to be required for the chemistry curriculum. Additional staff must be added in order to provide these courses. This is the other high priority for staffing.

In general, existing courses will not be used as a part of the chemistry curriculum beyond the first year. The possible exceptions to this are the existing second-year courses in physical chemistry and organic chemistry, which mightbe used by second-year chemistry students. Approximately 30 new courses will be required for the chemistry curriculum. Half of these will be taught in the first semester, and the other half in the second. A number of these are laboratory courses, which require large amounts of instructor time. Research is also costly in terms of instructional time. Staff to teach these courses are not currently available.

> Recommendation 7: The chemistry staff size should be increased by 10 within the first 3 years of operation of the chemistry curriculum.

> Recommendation 8: The chemistry staff size should be increased by an additional 5 members within the following 3 years.

This brings us to a staff with 15 members more than the present (1982-83) staff. This is consistent with the recommendations of the feasibility study.

It should be noted that substantial enrollment increases at the S_1 level are expected at IPB over the next 5 years. Since all first-year students at IPB take chemistry, additional staff will be needed to teach these new students. These additions have not been included in the recommendations above. However, it is important that faculty size in Chemistry be large enough that the workload of chemistry faculty be similar to that of other faculty in the basic sciences and mathematics.

INSTRUCTIONAL MATERIALS

The need for textbooks and other instructional materials in Bahasa Indonesia has been cited above. At present, it appears that each Chemistry department in Indonesia prepares its own translation of English-language materials, even though in a number of cases it appears that several institutions are using the same English-language source. We believe that a significant savings in time and resources could be achieved if institutions would share responsibility for translations.

> Recommemdation 9: The Chemistry Department at IPB should take the lead in coordinating English-language translation activities in chemistry in Indonesia.

FACILITIES AND RESOURCES

Adequate training in chemistry requires that students learn a variety of laboratory skills. This, in turn, requires that adequate laboratories, equipment, supplies, and chemicals be available. In

the absence of a detailed curriculum, it is not possible for us to make recommendations concerning amounts of materials and supplies. We note that at most Indonesian universities, students take two laboratory courses each semester. This requires extensive facilities and resources.

> Recommendation 10: High priority should be given to acquiring equipment, supplies, and laboratories adequate to develop a modern chemistry curriculum.

One particular facet of modern chemistry must be mentioned here: The use of instruments. A practicing chemist must be familiar with a wide variety of apparatus, including balances, pH meters, spectrophotometers, vacuum systems, chromatography equipment, etc. Students must have an opportunity to use such instruments.

Instruments for use in a Sarjana curriculum must be purchased with care. All such purchases are expensive, and it is important that they be made wisely. We hope that each instrument will last for a number of years (usually about 10 years). During that period, the instrument must function reliably with a minimum of attention. Maintenance and repair must therefore be simple and easy. Since many students will use the instrument, it must be sturdy and not easily broken.

We believe that for a Sarjana program it is more important to have simple, reliable equipment than to have sophisticated, state-of-the-art equipment. Students can learn the principles of gas chromatography as well using a very simple gas chromatography (costing $1000-2000) as they can using a very expensive one ($10,000-20,000).

LIBRARY RESOURCES

Chemistry students at the Sarjana level must learn to use journals and standard reference works in chemistry. They will need these skills later in their professional lines.

> Recommendation 11: High priority should be given to development of a library collection of chemistry reference works and journals.

This collection must be chosen with care. A relatively complete library in chemistry is expensive, and it is not needed.

The principal sections of this collection should be:

1) Standard reference books, including handbooks containing properties of compounds, book containing methods for preparation, analysis, etc.

2) A variety of standard chemistry textbooks, including both S_1 and S_2 level books.

3) A small collection of more advanced monographs in fields of particular interest (e.g. food chemistry, industrial chemistry, natural products chemistry, etc.).

4) A small collection of significant chemistry journals.

THE CURRICULUM

We make no specific recommendations concerning the content of the chemistry curriculum at this point. However, several observations may be useful.

The Ministry of Education requires that the Sarjana program contain at least 144 credits plus a seminar and a scripsi. Experience at other Indonesian universities suggests that it is not possible for most students to finish an S_1 program in 4 years. In fact, many students fail to finish even in 5 years. Chemistry is a difficult subject, and perhaps this is not surprising.

The beginning of the Chemistry program at IPB will coincide with the institution of the full-credit system in Indonesian higher education. The Chemistry staff will have an excellent opportunity to use the full-credit system to develop a flexible approach to education which allows different students to progress at different rates.

RELATIONSHIP BETWEEN CHEMISTRY AND BIOCHEMISTRY

At the present time, the staff in biochemistry at IPB is better established and stronger than the staff in chemistry. A number of biochemistry staff members also have extensive training in chemistry. The subjects of chemistry and biochemistry share a common base.

Plans are currently being formulated for development of a Sarjana program in biochemistry. We believe that the staffs in chemistry and biochemistry should work together to strengthen both their programs.

Biochemistry majors and chemistry majors often take the same courses during the first two years of a Sarjana program. In U.S. universities, students in both groups take the same courses in general chemistry, analytical chemistry, organic chemistry, and sometimes physical chemistry during their first 2 1/2 years. Thereafter, their programs diverge. Chemists take more physics and mathematics. Biochemists take more biology.

We believe that biochemistry staff and chemistry staff could work together for the common good. Specificially,

Recommendation 12: A shared set of courses in organic chemistry, analytical chemistry, and physical chemistry should be developed for the second year of the Sarjana programs in chemistry and biochemistry.

Recommendation 13: Biochemistry staff with appropriate expertise in chemistry should be enlisted to participate in the teaching of these courses.

In addition, more advanced courses in chemistry should be available as electives for biochemistry students. More advanced courses in biochemistry should be available as electives for chemistry students.

CONTINUATION OF WORK BY SHORT-TERM SCIENCE ADVISERS

After our return to Madison, we will carry out the following activities:

1) Collect and send chemistry textbooks and journals to IPB staff for use in training staff and developing curricula.

2) Assist the two IPB chemistry staff members who will study at UW-River Falls with their adjustment to American education.

3) Collaborate with chemistry and education faculty at River Falls to help them design appropriate graduate programs for IPB staff who will study there.

4) Assist IPB staff who will study in Madison (S. Achmadi, L. Darusman) to plan and carry out graduate work in chemistry.

5) Identify other American colleges and universities which could offer appropriate chemistry graduate degree programs for IPB staff.

Work at IPB during subsequent visits could include the following:

1) Work with chemistry staff to improve first- and second-year services courses in areas such as course content, teaching techniques, exam techniques, preparation of course materials, etc.

2) Assist in the development of the Sarjana program in chemistry, including advising on course offerings, course content, options for students having differing interests, development of advanced-level laboratory courses, etc.

3) Assist in development of the Sarjana program in biochemistry.

4) Advise on development of S_o programs, especially in training teachers in science, mathematics, and chemistry.

5) Work with IPB administration on curriculum evaluation (continuation of the work that was started during the first visit).

Possible times for return visits include one to two months during the period November to January, 1983-84 or June to August, 1984.