DOCUMENT RESUME

ED 076 432 SE 016 136

AUTHOR McCollom, Kenneth A.; Kurtz, Edwin B.
TITLE An Integrated Preprofessional Individually Paced Instruction Curriculum.
PUB DATE [73]
NOTE 13p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS Behavioral Objectives; *Course Organization; Curriculum Development; *Engineering Education; *Individualized Instruction; Instructional Materials; *Integrated Curriculum; Pacing; *Program Descriptions
IDENTIFIERS Self Paced Instruction

ABSTRACT

The individually-paced instruction program carried out by the engineering faculty at Oklahoma State University is described in this article to illustrate its goals, principles, characteristics, developments, and present status. The instructional model is discussed in connection with behavioral objectives, criteria for performance, and student self-pacing and achievements. Closely related preprofessional courses are integrated to cover 40 credit hours of mathematics, chemistry, physics, speech, English, computer science, graphics, and logic. Instructional activities consist of text assignment, laboratory work, audiotutorial tapes, sample problems, informal group discussions, and a computer managed system. A flowchart representing the module hierarchy is provided. Students who have satisfactorily evaluated their competency are assigned the subsequent module. Learning difficulties are diagnosed if students fail on tests. To start learning at a point that matches learner's competence level is permitted. After the 1971 pilot program, seven departments have been involved in preparation of materials. The integration is more complete, and further improvements are expected on the basis of the present experimental version. Also discussed are the physical facilities and education research developed for the program. (CC)

AN INTEGRATED PREPROFESSIONAL INDIVIDUALLY PACED INSTRUCTION CURRICULUM

by

Kenneth A. McCollom
Assistant Dean of Engineering
Oklahoma State University
Stillwater

and

Edwin B. Kurtz
Chairman of ~~Biology~~ Life Science
~~Kansas State Teachers College~~ Univ. Tex. Permian Basin
~~Emporia~~ Odessa, Tex.

Engineering education has been plagued for many years by the enigma of high attrition of students who enter the program saying that they want to be engineers. Attrition is in part due to a change in motivation of the student. But engineering faculty have been more concerned with the loss of motivated students who are unable to achieve success in courses taken prior to the engineering part of the curriculum. Much of the cause for attrition is then attributable to the basic courses in arts and sciences.

A search was made by engineering faculty at Oklahoma State University for an instructional model that would maximize achievement for a major portion of the students who are motivated to start the engineering curriculum. Under the leadership of Lee Harrisberger as chairman of the Center for Teaching, a model was identified and a program of development and implementation was begun.

The Model

The instructional model that was adopted is one in which a hierarchy of instructional objectives in behavioral terms is constructed for a course. Following this the criteria or standard of performance by which the students will be evaluated is described. Next assessment tasks are made for use in determining whether a student has achieved each of the instructional outcomes specified by the objectives. Only after these steps have been completed is the instructional method considered. The faculty at Oklahoma State have moved toward an individually paced instructional format which appears to permit a larger percentage of students to attain the objectives of the course as compared to the usual method of instruction in which students are locked in with time. Inherent in this model are the opportunity and necessity for each student to assume much greater responsibility for his own learning. With a greater opportunity to actively "inquire" rather than passively "acquire," the student should become a more capable and self-actualizing person -- a goal of all higher education.

This model of instruction has many of the characteristics described and implemented previously (1, 2, 3, 4, 5). However, the preprofessional program as developed at Oklahoma State University has one major and unique characteristic that has not, to our knowledge, been attempted previously in higher education; that is, the preprofessional courses that are closely related are integrated within the same model. The integrated model now being implemented includes forty credit hours of mathematics, chemistry, physics, and communications (speech, English, computer science, graphics, and logic). How this integrated model was developed, the rationale for its use, a description of the integrated instructional hierarchy and activities, and a description of the implementation of it follow.

Development of the Model

The College of Engineering at Oklahoma State University is fortunate that a friend of the University has, for some years, regularly contributed several thousand dollars directed specifically to improve instruction in the College of Engineering. With these directed resources and with the concept of the model of instruction described above, several workshops on constructing instruction based on behavioral objectives were held for faculty. Each workshop involved the faculty for three days in an individually-paced instructional format, the objective of which was that the faculty would be able to construct instructional objectives, test items, and instruction based on objectives for their own college course (6). Through the workshops, faculty invariably found, particularly by using their own subject material, that this approach to organizing and systematizing the material for the students and themselves has tremendous potential.

The activities of the College of Engineering rapidly spread to the entire University and soon faculty from every department within the University were attending the three-day workshops. At the present time, approximately one-th...

of the nine hundred or so faculty members at Oklahoma State University have participated in the workshops. Throughout the University, isolated courses have been converted to the self-paced format based on behavioral objectives. Some professors have even stated that they could never again teach a course without first stating objectives of the course for both the students and themselves. The point is that a significant change of attitude and approach toward instruction of a significant number of faculty provided an atmosphere in which another step could be attempted -- that of integrating several courses. Undoubtedly it was necessary to have this large number of professors exposed to the instructional model before the process of integration of courses could be attempted.

Rationale for the Preprofessional Individually Paced Instruction Program

The Preprofessional Individually Paced Instruction (PIPI) Program at Oklahoma State University integrates freshman and sophomore level mathematics, physics, chemistry, and written, oral, graphical, and computer communications into the individually paced instruction model. The academic goals of the PIPI program were stated as follows:

(1) Provide a self-paced study program to meet all professional school entrance requirements in mathematics, science and communications that can be achieved by ninety percent of all students in two calendar years or less;

(2) Provide a study program of uniform quality, content and achievability that can be administered on any campus to students having college-level scholastic potential regardless of differences in precollege preparation;

(3) Develop a learning system that will optimize the utilization of self-study aids and will demonstrate cost effective instruction.

Some of the basic principles upon which the PIPI program is based and a brief comment on how each of these principles was implemented are:

(1) Because students have different learning styles, students should be provided with alternative sets of instructional activities.

Several different written instructional activities, and multimedia presentations where appropriate, provide the student who does not achieve success with one instructional activity an alternate path for the next attempt.

(2) Because students do learn at different rates, activities for individuals or small groups are essential to accommodate this difference.

The program provides for individually paced instruction in most cases with group activities where needed, such as in the communications sequences.

(3) Because students come with different sets of competencies, the competencies a student already possesses must be identified and instruction begun at that point.

Pretests for the modules of learning in each subject area are used to establish where the student starts in the integrated curriculum.

(4) Learning and retention are enhanced by assuring that prerequisite competencies are identified and used across the preprofessional curriculum.

Faculty from all the subject areas work closely together to establish competencies for each module. Prerequisites include competencies which are in their own subject areas and also in other subject areas.

(5) Because continuing success in the preprofessional curriculum depends upon prerequisite competencies, these competencies must be mastered at an "A" grade level.

The criteria for assessing the student's ability for a particular objective is defined as the "mastery level" and the student does not proceed until he achieves at this level. He may repeat the unit as often as necessary, without penalty, until mastery is achieved.

(6) Unless the student can apply his newly acquired competency in a variety of situations, he has not learned.

The assessment items are designed to test the student's newly learned competency in situations not used in the instruction; thus the student must be able to transfer his learning just as he will need to do "on the job" or in subsequent learning.

(7) Because students must be prepared for life-long learning by self-study, provide the student with the self-study skills while he is a preprofessional.

The model of individually paced instruction places the student in a system for self-study which is rather carefully controlled; this should prove of reasonable value as he moves into less structured self-study situations.

Instructional Hierarchy and Activities

The self-paced program as developed in this model has a hierarchy of behavioral objectives. That is, each module of a course has one or more objectives stated or described in performance terms. The objectives describe what the student must be able to do that can be observed and measured under specified conditions as evidence that he has learned. All statements are written with "do" verbs such as demonstrate, describe, construct, derive, identify, and so forth (6).

A flow chart (hierarchy) of the modules (units of instruction) was constructed so that prerequisite competencies are achieved prior to the module for which they are needed (1). This assures that first things are learned first and the following tasks capitalize on and reinforce competencies learned earlier (Figure 1).

The typical module has a terminal objective and several subordinate or enabling objectives. A typical course, one semester in length, contains about fifteen modules, although the number of modules actually used by a student will be determined by the set of competencies he has acquired prior to beginning the course.

Each module or instructional unit also has a rationale and several alternative instructional activities such as text assignment, laboratory activities, programmed instruction, audio-tutorial tapes, sample problems, informal group discussions, and so forth. For use by the student after he has participated in the instruction, he may evaluate his newly acquired competence with test items that are matched to each of the objectives of the module. When the student is satisfied that he has mastered the module, he appears before the faculty member or graduate assistant and requests an individual assessment for that module. Upon completion of the test items his work is immediately reviewed with the instructor. If his work meets the standard of performance specified, he may begin study of the next modules in the hierarchy. If his work does not meet the standards, the instructor uses the student's responses to help the student diagnose his learning difficulties. The student then does additional instruction until mastery is attained.

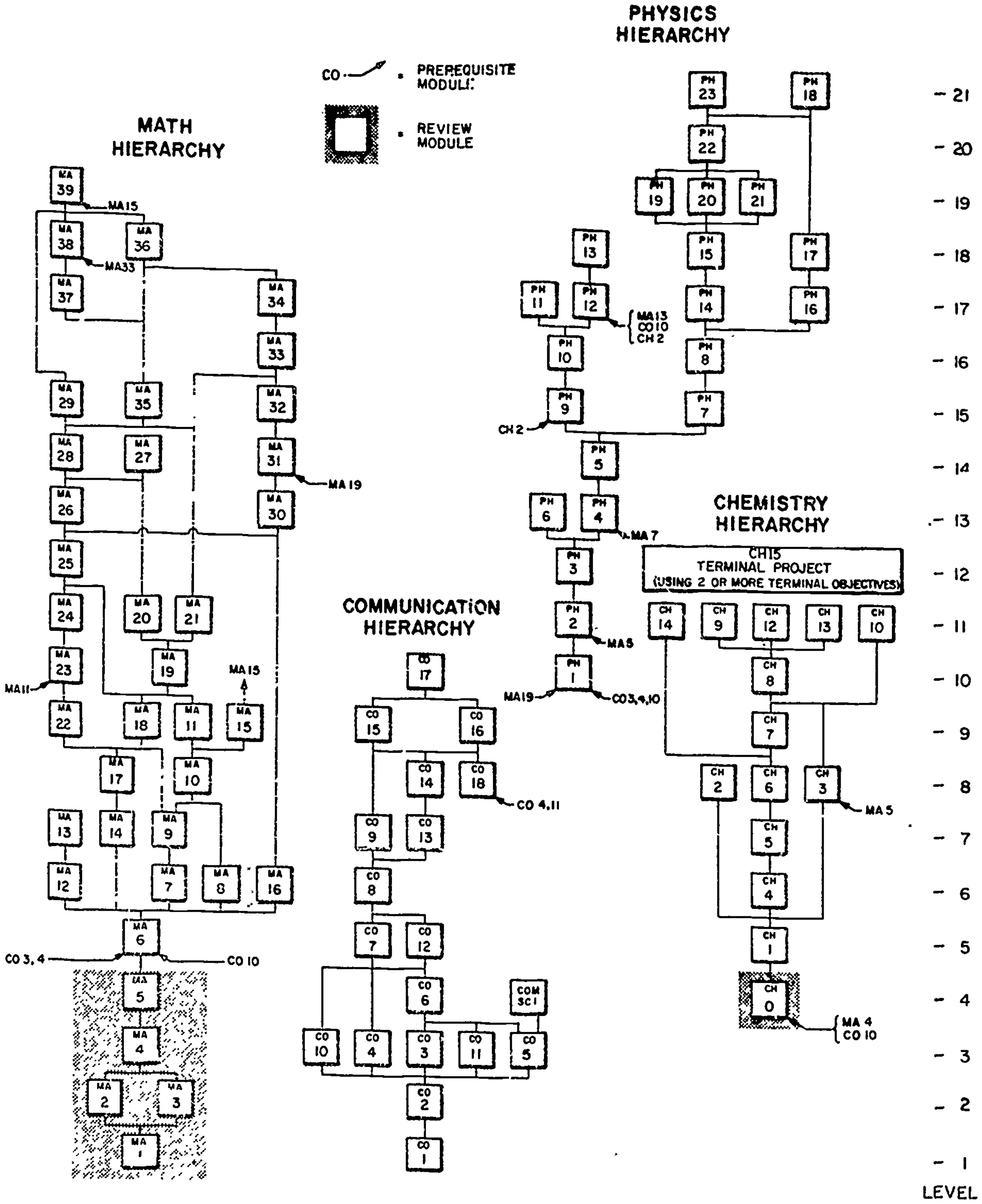

Figure 1. Integrated hierarchy of the PIPI Project. Each module of objectives and instruction is assigned a number. Titles of these modules are given in Table I.

MATHEMATICS

Math 1213 Intermediate Algebra
- MA 1 Arithmetic
- MA 2 Operations with Polynomials
- MA 3 Coordinate Systems
- MA 4 Equations
- MA 5 Quadratics

Math 1513 College Algebra
- MA 6 Functions
- MA 7 Logarithms
- MA 9 Polynomials
- MA 12 Combinatorics
- MA 13 Probability
- MA 14 Linear Algebra
- MA 16 Sequences

Math 1613 Trigonometry
- MA 6 Functions
- MA 7 Logarithms
- MA 8 Trigonometric Functions
- MA 9 Polynomials
- MA 10 Trigonometric Equations
- MA 11 Numerical Trigonometry
- MA 15 Complex Numbers

Math 1715 College Algebra and Trigonometry
- MA 6 Functions
- MA 7 Logarithms
- MA 8 Trigonometric Functions
- MA 9 Polynomials
- MA 10 Trigonometric Equations
- MA 11 Numerical Trigonometry
- MA 12 Combinatorics
- MA 13 Probability
- MA 14 Linear Algebra
- MA 15 Complex Numbers
- MA 16 Sequences

Math 1813 Analytic Geometry
- MA 17 Line in a Plane
- MA 18 Conics
- MA 19 Transformations
- MA 20 Polar Coordinates
- MA 21 Three Dimensional Analytics

Math 2055 Calculus
- MA 22 The Derivative
- MA 23 The Technique of Differentiation
- MA 24 Implicit Differentiation and Higher Derivatives
- MA 25 Applications of the Derivative to Graphing
- MA 26 Maxima and Minima
- MA 27 Motion on Plan Curves
- MA 28 Mean Value Theorem and Indeterminant Forms
- MA 29 Taylor's Series
- MA 30 The Definite Integral
- MA 31 Elements of Formal Integration

Math 2155 Calculus and Differential Equations
- MA 32 Integration Techniques
- MA 33 Applications of Integration
- MA 34 Infinite Series
- MA 35 Derivatives and Space
- MA 36 Multiple Integrals
- MA 37 Introduction to Differential Equations
- MA 38 First Order Differential Equations
- MA 39 Second Order Differential Equations

COMMUNICATIONS

English 1113, 1323; Speech 2713
- CO 1 Goal Setting
- CO 2 Nature of Communications
- CO 3 Communication Barriers
- CO 4 Mechanics of English
- CO 5 Information and Documentation
- CO 6 Discussion and Reading
- CO 7 Structure of Messages
- CO 8 Development of Messages
- CO 9 Writing Essays
- CO 10 Graphics
- CO 11 Logical Relationships
- CO 12 Interview
- CO 13 Private Problem Solution Discussion
- CO 14 Public Problem Solution Discussion
- CO 15 Public Persuasive Speech
- CO 16 Research Paper
- CO 17 Using Communications Skills on Unstructured Problem Situations

PHYSICS

Physics 2014
- PH 1 Vector Algebra
- PH 2 Kinematics
- PH 3 Dynamics
- PH 4 Gravitation
- PH 5 Energy Principles
- PH 6 Momentum Principles
- PH 7 Simple Harmonic Motion
- PH 8 Wave Propagation
- PH 9 Thermometry
- PH 10 Calorimetry
- PH 11 Heat Transfer
- PH 12 Kinetic Theory
- PH 13 Thermodynamics

Physics 2114
- PH 14 Electric Charge
- PH 15 Static Electric Fields
- PH 16 Capacitance
- PH 17 The D.C. Electric Current
- PH 18 Magnetic Fields
- PH 19 Induced Electromotive Forces
- PH 20 Electromagnetic Devices
- PH 21 Geometrical Optics
- PH 22 Physical Optics
- PH 23 Quantum Optics

CHEMISTRY

Chem 1364
- CH 0 Metric Measurement
- CH 1 Early Atomic Theory
- CH 2 States of Matter
- CH 3 Thermodynamics
- CH 4 Atomic Structure
- CH 5 Periodic Classification
- CH 6 Atomic Bonding and Structure of Compounds
- CH 7 Binary Compounds

Chem 1374
- CH 8 Acids and Bases
- CH 9 Electrochemistry
- CH 10 Rates of Chemical Reactions
- CH 12 Precipitation Reactions
- CH 13 Complex Ions
- CH 14 Organic and Biochemistry
- CH 15 Terminal Project

Table I. Courses and titles of modules in the PIPI program.

In the PIPI program, a student is pretested and is permitted to start learning at a point that matches his competency level. Once in the curriculum, a student can move at his own pace. If he accomplishes the objectives of a given course segment in half of a semester, he is given credit and can initiate the next segment immediately. On the other hand, if he takes a little longer than a semester, he is not penalized. The important thing is that he finishes the objectives at a mastery level.

One important facet of the PIPI program is that time spent in the classroom lecture is significantly decreased. Most of the time is spent with materials prepared by the instructor, with the instructor on a one-to-one basis or in small discussion groups. This results in little of the student's class time being scheduled in the traditional "time and place" manner. The needs of the student are met more at the convenience of the student as the needs arise.

Implementation of the PIPI Model

Physical Facilities. The physical facilities that have been developed for the program include interaction rooms with conference areas where instructors are available to talk with students who have problems in any of the PIPI subject areas or for assessment of objectives in a module. These rooms also have areas for working on the tasks involved in the assessments. There are small group discussion areas, a physics lab and a physics interaction room. There is also a PIPI resource room which provides reference materials, enrichment reading materials, and a place to talk to other students. The PIPI impact room is the general office. It is also a place to inquire, complain, or offer suggestions about any phase of PIPI. PIPI activity is not limited to the center since much of the chemistry instruction takes place in a laboratory in another building where facilities are already installed. Also scheduled group meetings of various kinds occur in different parts of the campus.

The common area where students can find assistance and be evaluated in all of the subject areas tends to make more efficient the progress of the student through the integrated course curriculum of this preprofessional package. The student is able to get assistance in several subject areas at essentially the same time in the same physical area. Interaction between faculty from different subject areas is also greatly increased.

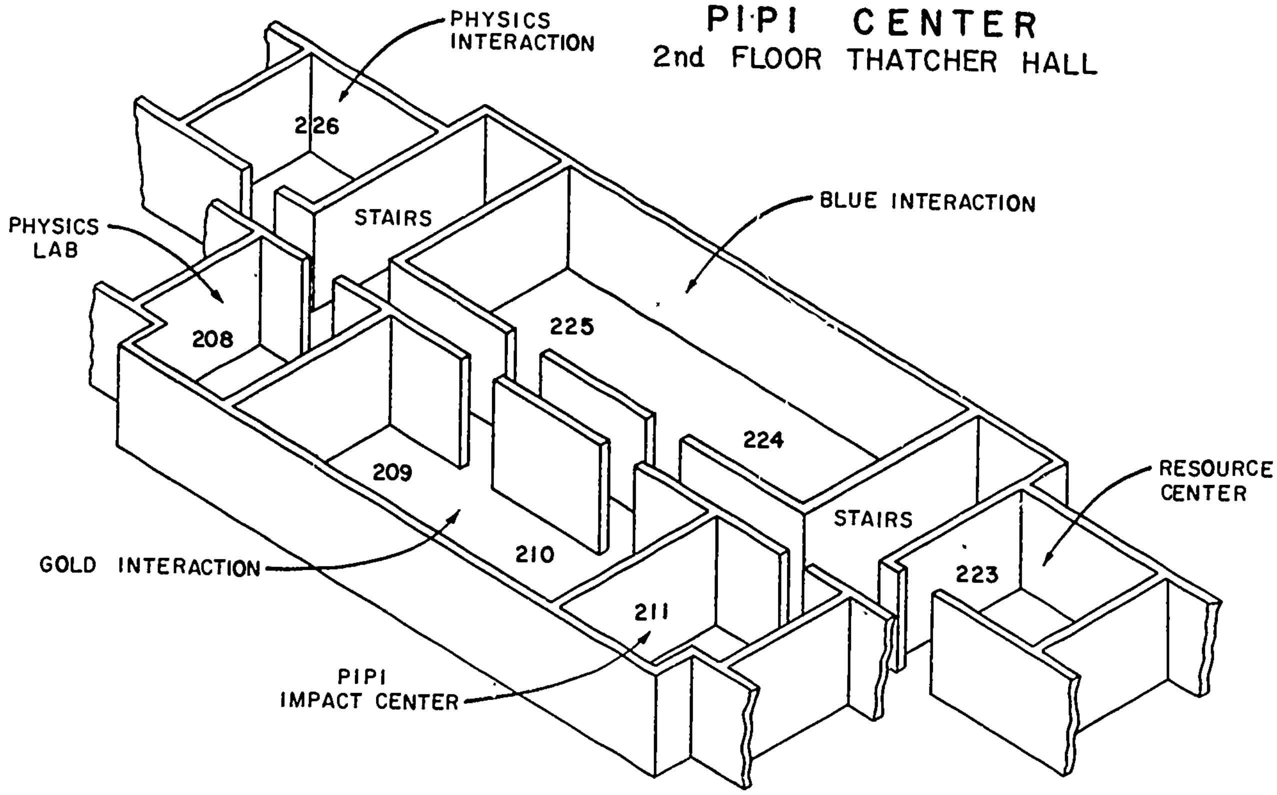

Figure 2. PIPI center for mathematics, physics, and communications. Computer science and chemistry facilities are available elsewhere.

Educational Research. Much of the research being conducted with this instructional model will be toward evaluation of the students' ability to reach the mastery level in a reasonable length of time. The difference between self-pacing and procrastinating is difficult to determine because students learn at different rates. If the rate of learning can be predicted for each student, the instructor can contact the student who does need special help knowing that he is behind his own predicted rate of learning.

A significant problem in self-paced programs is to get a student started who is not used to this type of responsibility. Although the student is not harmed by being "behind" as in a standard course and being irreparably damaged in terms of his learning, the student must get started or he will not learn at all. Some students require more structuring and deadlines and are used to the penalties and reward system normally encountered in most high schools. This type of student is likely to be a procrastinator in this instructional system and needs to be identified early and given sufficient structure long enough to get him started in the class and to start assuming responsibility for his learning.

Another area of research is to determine if the instructional units in the integrated hierarchy of the preprofessional curriculum are indeed doing the job they were designed to do. This validation is of the utmost importance if the goals for the program are to be met.

These research questions are being investigated through both student attitude and student achievement measures. Comparisons are being made between the PIPI classes and conventional classes in the same subject areas. Students will also be interviewed formally and informally to try to describe their attitude about university learning and the effect that PIPI may have had on them.

Status of Program. During the fall semester, 1971, a pilot program involving approximately three hundred different students in six different courses of the PIPI curriculum was implemented. This was partly supported by funds from the National Science Foundation.

The project is expected to be under continuous development for at least three years before any reasonable stability of the program can be anticipated. Evaluations made each semester will provide data upon which to base subsequent revisions so that effectiveness should improve with each experimental version.

Instructional materials are being created by fourteen different faculty from seven different departments in the University. This requires considerable coordination and close multidisciplinary study on the part of the faculty. In general, this has proven to be quite stimulating to the faculty and no person assigned to the project since its inception a year and a half ago has dropped by the wayside. Enthusiasm is high and is only exceeded by the amount of work necessary to implement such a project in anything like a successful way.

The PIPI system essentially requires a computer managed instruction (CMI) system to relieve the faculty and staff of many minute details inherent in this kind of program. During the pilot program this is not being done, but preliminary work has occurred to adapt a quite complex computer managed instruction program to this PIPI project. The conclusion is that a complex system is not the most optimum for routine logistical details and feedback. Thus, the very complex systems available have been abandoned in favor of creating a rather simple system to keep track of progress of individual students and compare the statistics of progress of groups of students through the program. A more complex system possibly would be of value later, but the most important thing is to make efficient the operation of the faculty and their time. This can be accomplished with a simple CMI program.

Considerable development will be necessary to bring the complete PIPI program to a satisfactory condition. At the present time the faculty are managing to stay ahead of the students in terms of these instructional activities, but are not convinced that they have refined the modules to the point where they will be most effective. This will take considerably more effort including full time preparation of materials during the summer of 1972. This period of time will allow the replacement of modules that were not as successful as desired and also permit construction of additional instructional activities to allow more alternative paths.

Conclusions

Although individually paced instruction using objectives described in behavioral terms has been used extensively in secondary education and to a certain extent in higher education, the combining in an integrated hierarchy of closely related courses has not been accomplished to our knowledge. The potency of having closely coordinated activities of learning across these preprofessional subject areas is unquestioned in our minds. In addition, the interaction of the large number of faculty across seven disciplinary departmental lines is very stimulating and very productive in terms of reaching the end goal of a better learning situation in these subject areas.

There is a need to point out that the preprofessional students in the subject areas of engineering, mathematics, chemistry, and physics are not the only persons who can profit from the materials and their integration as described in the PIPI model. A significant number of other professional areas can take a subset of the modules shown in Figure 1, and reach their own objectives even to the point of creating relevant instructional activities in their own professional area based on the same hierarchy of objectives encountered in the preprofessional areas. The communications package itself is essentially universal.

Perhaps the communications package that integrates written, oral, graphical, and computer communications together with some logic into one package with some common stems is the most innovative and new concept of curriculum itself evolving from the PIPI project. Here the integration is more complete than just taking prerequisite modules across subject areas because competencies in common to the different means of communication have been integrated into a common set of learning activities.

Literature Cited

1. Gagné, R.M. (1970). The Conditions of Learning, second edition, Holt, Rinehart and Winston, Inc., N.Y., N.Y.

2. Mager, R.F. (1962). Preparing Instructional Objectives, Fearon Publishers, Palo Alto, Calif.

3. Kapfer, M.B. (1971). Behavioral Objectives in Curriculum Development, Education Technology Publications, Englewood Cliffs, N.J.

4. Block, J.H. (editor) (1971). Mastery Learning, Holt, Rinehart and Winston, Inc., N.Y., N.Y.

5. Keller, F.S. (1968). "Good bye Teacher ...," Jour. Applied Behavior Analysis 1:79-89.

6. Walbesser, H.H., E.B. Kurtz, L.D. Goss, and R.M. Robl (1971). Constructing Instruction Based on Behavioral Objectives, Engineering and Industrial Extension, College of Engineering, Oklahoma State University, Stillwater, Okla.