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ABSTRACT

The individualized community college calculus course described here was developed to accomodate differences in student learning rates. It consists of three units: (I) limits and continuity; (II) the derivative with applications; and (III) the integral with applications. There are three sections in Unit I, four sections in Unit II, and five sections in Unit III. The student must pass an examination on each section before he/she may proceed to the next section. An examination for a given section may be repeated only twice, and the amount of points allotted for the examination decreases with the number of tries necessary to pass it. Although the course carries three units of credit, the student may elect to complete only one or two of the units in one semester and to finish the course during the subsequent semesters. Each student works with video-taped lectures and a textbook; regularly scheduled question-answer sessions and personal assistance are also available. The goals and behavioral objectives for each unit are detailed, and sample assignments and exams for Unit I are included. (DC)

A Student-Oriented Individualized Learning Program for Calculus at the Community College

by

David K. Blough

OUTLINE

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INTRODUCTION:

BACKGROUND AND CURRICULUM DESIGN

A STUDENT-ORIENTED INDIVIDUALIZED LEARNING PROGRAM FOR CALCULUS AT THE COMMUNITY COLLEGE

At the community college level there has been in recent years substantial increases in student enrollment. Even though the community college has historically been characterized as a "personal" institution where class size is small, it is evident that soon this aspect may be overcome by the flood of students. For the instructor, this means the time devoted to individual help and guidance of students may not merely decrease, but disappear altogether. Hence, with the nontraditional increase in enrollments, it is necessary to develop a nontraditional approach to education.

Those things which teachers do best can be classified into four areas: diagnose individuals' learning problems, interact with individuals on a one-to-one basis, inspire and motivate, and encourage creativity.[1] The traditional lecture-format for instruction many times fails to give teachers the opportunity to practice these objectives due simply to lack of time. Thus it is apparent that the responsibility of learning must be turned over to the learner himself; this lets the instructor allocate time to individuals while the group progresses on its own. In addition,

[1]Stuart R. Johnson and Rita B. Johnson, Developing Individualized Instructional Material (Palo Alto, California, 1970), pp.4-9.

it allows the student to progress at his own rate of speed, an important characteristic not found in the lecture-format type of instruction.

That individualized learning has these benefits is nothing new. It was conceived concurrently with many technological advances in such areas as systems research and audio-video developments. So it is the purpose of this discussion to apply these well-established concepts to a particular case in point--Calculus. This class is considered because in the community college transfer students majoring in the natural sciences, the social sciences, or mathematics are required to take this course. It is the foundation of many diverse disciplines. In another sense, first semester (quarter) Calculus represents for many students a traumatic introduction to "true" mathematics. It stands as the dividing line between easily-conceptualized, rote-learned arithmetic and non-intuitive, theoretical, higher mathematics. It should be noted that by non-intuitive I mean the student usually finds concepts and abstractions with little or no counter-part in his past educational experiences or in "everyday life". Also, the introduction of new notation and symbols to explain these concepts often leaves the individual with no understanding of mathematical thinking in general. It is for these reasons that an individualized learning program for the Calculus is necessary.

Before the actual outline of the class can be given, some definitions are necessary in order to establish the learning system framework upon which the mathematics will fit. Consider first what is meant by learning. Basically there are three types of learning: psychomotor, affective, and cognitive. By the nature of mathematics itself, especially at the Calculus level, learning will be understood here to mean cognitive learning. In other words, this is learning requiring the intellectual processes of remembering, understanding, and problem solving.[2]

There are basically three steps involved in the individual learning system: goals must be specified, objectives designed for attaining those goals, and finally the instructor and student as well must have some objective method for ascertaining or measuring the degree to which the objectives have been learned.[3]

A viable definition of goal is what the student should or would like to be able to do by the end of the learning activities.[4] It should be noted here that the goal stated should be something meaningful and not trivial. Similarly, it should not be confused with the measuring device (see below) used to ascertain acquired ability. For example, consider a goal such as:

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[2]Ibid., pp. 5.

[3]Robert Mager, Preparing Instructional Objectives (Palo Alto, California, 1962), pp. 7-9.

[4]Albert R. Wright, "Beyond Behavioral Objectives," Educational Technology, 33(July, 1972), 9-11.

> The student is to be able to complete a 100-item, multiple choice examination on the subject of marine biology. The lower limit will be 85 items answered correctly within an examination period of 90 minutes.[5]

In terms of the definition just given, this is clearly not a goal. Though it does indicate something about marine biology, it states no purpose to learning other than passing the examination. This confusion produces the same short-sightedness in results as is so often found in a more traditional approach to education.

Perhaps a more comprehensive definition as given by Mager is required. He feels a goal is simply what is to become of the student, i.e., attitudes or abilities to be gained.[6] As will be seen later, the innate structure of mathematics will naturally lend itself to the precise formulation of goals.

Consider now the means to achieving the stated goal, behavioral objectives. By defining objectives as specific, observable student actions or the products of student action, we can characterize an objective in two ways. First it must specify something which the student is to do. Next it must precisely state the circumstances under which he will do it.[7] Mager's excerpt, as stated above provides an excellent example of a behavioral objective.

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[5]Mager, pp. 15.

[6]Mager, pp. 12.

[7]Mager, pp. 15.

The second criteria lends itself to the measurement of ability. By now specifying the degree of accuracy with which the student will perform the action, the final aspect of individualized learning is taken into account. The point of importance here is to be specific in designating this degree of accuracy. For example,

> The student will take a 60 minute test with no textbooks, tables, calculators, or slide rules on applications of the derivative. There will be 10 questions, and the lower limit will be seven answered correctly.

No ambiguity can arise here, and this fact is essential for student as well as instructor.

This concept of goal--objective--measure has been applied in almost every discipline at the community college level, and although some courses lend themselves to this system better than others, it at least provides an alternate approach to lecture-format instruction. In particular, there have been numerous such constructions of a first semester Calculus course, and it is not the intention of this discussion to simply redo one of these systems. On the other hand, it is apparent that the published individual learning systems offered in most texts on the subject are designed primarily for the instructor. Hence, the purpose of this discourse will be to take a particular modular-organization of the Calculus, and present an outline of the translation of this system into one designed especially for the student himself.

After all, since he is the teacher-learner in this situation, all goals, objectives, and examination procedures should be made clear to him at the start. In addition, a description of the curriculum design needed for the course will be included in order to expand upon the "individualization" of the system. This will include audio-visual cassette records, a concept which will be adapted from a plan in current use to teach Elementary and Intermediate Algebra in the Mathematics Department at the University of Arizona. It should be noted that the system at Arizona was initiated in order to deal with enormous classes in Algebra (500 students and more), and hence will be all the more effective for smaller classes.[8]

So with this brief background in individualized learning established, it will be the goal of this paper to graft together the instructor's program package with audio-visual and other instructional techniques in order to produce a student-oriented package, made available to the student on his first day of class in Calculus. A comprehensive outline will be presented, with elaborative details on only the first unit. This is done because curricula and facilities will vary within a given mathematics department, as well as from institution to institution, and adaptive

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[8]Richard Thompson, Intermediate Algebra (Tucson, Arizona, 1974), pp. 1-3.

changes would be required accordingly. Following this outline will be a conclusion including recommendations for implementation of the system.

Curriculum Design

As noted before, there exist already many individualized as well as lecture-type systems of behavioral objectives for first semester (quarter) Calculus. In order to develop the following system with some degree of comprehensiveness as well as generality, eleven catalogues of California community colleges were scanned for their Calculus offerings. A synthesis based upon these was arrived at.* (California was chosen due to my particular interest in that state.) Also it was found that the behavioral objectives for a Calculus course as presented by Michael Capper yielded a fairly consistent point of departure encompassing course offerings in the majority of these catalogues.[9] Hence, Capper's objectives will serve as the basic outline for the course with the following modifications: objectives concerned with a review of algebra will be omitted since my program would otherwise duplicate other programs already in existence (as at the University of

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[9]Michael R. Capper, "Instructional Objectives for a Junior College Course in Calculus and Analytic Geometry," ERIC (U.C.L.A., 1969).

*Included were Ventura College, Foothill College, Allan Hancock College, College of Marin, Contra Costa City College, Evergreen Valley College, Los Angeles City College, Napa College, Rio Hondo College, Riverside City College. These colleges were chosen from various geographic areas and population concentrations over the state in order to obtain a somewhat "randomized" sampling.

Arizona). If there is a need for a particular class or other population of students to review algebra, this can be inserted accordingly. Also, the textbook which Capper uses will not be used in this discussion due to my unfamiliarity with its design. Instead, Calculus with Analytic Geometry: A First Course by Protter and Morrey will be used. The outline which follows includes limits and continuity, the derivative with applications, and the integral with applications. Goals and objectives will be outlined for all three units, with a complete learning program developed for Unit I. As mentioned previously, it will be noted that beginning at the Calculus level, mathematics takes on the form of "definition--theorems--examples", a rigorous form which lends itself well to the formulation of goals and objectives. It also facilitates logically-graduated learning.

The first unit will be divided into three sections, and the student must pass an examination on each section before he can proceed to the next. An examination will consist of from 5 to 10 questions with a constant total possible point value of 60 points. Each examination must be completed within 50 minutes with no reference material such as textbooks, tables, or calculators available.

The design for the course is as follows: the student has the textbook, video-taped lectures, regularly scheduled question-answer sessions, and personal help from the instructor available to him. The class will meet three times a week, Monday, Wednesday, and Friday for fifty minutes each period. The purposes of these periods are (1) to take examinations, and (2) to ask the instructor questions in a classroom setting. These are not formal lecture periods. If the student wishes to see a lecture on some particular topic, he may check out the desired video-tape at any time during the week. Additional questions on material will be answered by the instructor at either designated office hours or by mutual agreement on a time with the student.

It is manditory that the instructor either have teaching assistants to administer exams while he conducts the question-answer session, or work in tandem with another instructor, thereby combining two classes. Also, it is evident that two classrooms per meeting are required, one for exam taking, the second for question asking.

Students are free to take an examination any time they feel ready, subject to the following conditions:

1) A minimum of 40 points per examination is needed to pass.

2) An examination for a given section may be repeated, but only twice.

3) Second tries at an examination still require 40 points to pass, but only 2/3 of the earned points go toward the student's final grade.

4) Third tries at an examination still require 40 points to pass, but only 1/3 of the earned points go toward the student's final grade.

Exams, once taken by a student, will be kept on file by the instructor and can be reviewed by the student at designated hours. The exam always remains with the instructor, but he will answer any questions concerning a student's performance on a given exam.

The suggested course of study for a particular section is as follows:

1) The student should first view the appropriate video-taped lecture.

2) He should then read the corresponding material in the textbook.

3) He should do the problem assignments in the textbook (answers are given at the end of the text).

4) He should attend the question-answer session to clear up any areas of difficulty.

5) If more help is required, he should see the instructor during office hours.

6) He should complete all behavioral objectives under the listed restrictions.

7) He should take the examination.

Variable Credit

This is a three unit course. There are three units (Limits and Continuity, Derivatives, Integrals), and there are three sections in Unit I, four sections in Unit II, and five sections in Unit III. Hence, since the student must take one exam per section, there is a total of twelve exams to be taken, approximately one per week. If, during the semester, the student falls behind this pace, he may elect to complete only eight exams, thus receiving only two units of credit for the course. He may begin the following semester with section 9 to complete the final unit of credit. Similarly, he may complete only the first four sections, obtaining one unit of credit and continue the class in subsequent semesters. This variability is built in to accomodate different students' different rates of learning.

CALCULUS: BEHAVIORAL OBJECTIVES

UNIT I

LIMITS AND CONTINUITY

Included in this unit are basic definitions of the limit, theorems on sums, products, and quotients, finite and infinite limits, and the definition of continuity and its graphical representation.

I. Goal: The student will know and be able to apply the definition of limit.

Objectives: 1) The student will in 5 minutes, with no references, define "finite limit" with 90% accuracy.

2) The student will in 5 minutes, with no references, define "infinite limit" with 90% accuracy.

3) Using a "δ-ε" proof, the student will in 10 minutes with no references, prove an "obvious" limit with 75% accuracy.

4) The student will in 5 minutes with no references, give an example of a function which does not have a limit at some point in its domain with 100% accuracy.

II. Goal: The student will be able to state, prove, and use theorems on limits of sums, products, and quotients.

Objectives: 5) The student will in 5 minutes state a given limit theorem with no references, with 90% accuracy.

6) Given a mathematical statement involving limits, the student in 5 minutes with no references, will be able to cite the limit theorems which justify it with 100% accuracy.

7) The student will prove a limit theorem as directed with no references, with 70% accuracy.

III. Goal: The student will be able to define and interpret graphically the concept of "continuity."

Objectives: 8) The student will define "f is continous at x" in 2 minutes with 100% accuracy and no references.

9) The student will give a "δ-ε" proof of "f is continuous at x" for a given f and x with 80% accuracy.

10) Given "f undefined at x_0," how should f be defined so that f is continuous at x_0? The student will have 10 minutes, with 100% accuracy, no references.

11) The student will give an example of a discontinuous function, no references, in 5 minutes, with 100% accuracy.

Assignments (in Protter, Morrey)*

Section 1, video tape 1:	Read pp. 66-72, do problems 7, 9, 11, 12, 15, 18, 23.
	Read pp. 73-75, do problems 1, 5, 10, 15, 20.
	Read pp. 97-101, do problems 3, 6, 9, 12, 15, 18, 21.
Section 2, video tape 2:	Read pp. 102-107, do problems 1, 2, 3, 8, 9, 17, 19, 21.
	Read pp. 115-119, do problems 1, 4, 10, 17, 20.
Section 3, video tape 3:	Read pp. 108-113, do problems 1, 3, 9, 13, 17, 20.

*These problems assigned are only a suggested minimum! The student should do as many as possible in each section of the textbook.

EXAMINATIONS FOR UNIT I

1. Given: A function f, and numbers a and L. Define "the limit of f(x) as x tends to a is L."

Compute the following limits:

2. $\lim_{x \to 3} (x^2-9)/(x^2-5x+6)$

3. $\lim_{x \to 2} (\sqrt[3]{x}-\sqrt[3]{2})/(x-2)$

4. $\lim_{h \to 0} 1/h(1/\sqrt{x+h}-1/\sqrt{x})$

5. $\lim_{h \to 0} (1/h)(2(5+h)^2+3-(2\cdot 5^2+3))$

6. The numbers a, L, ϵ are given. Determine a number δ such that $|f(x)-L|<\epsilon$, for all x such that $|x-a|<\delta$. Draw a graph.

   $f(x)=1/x$, $a=2$, $L=\frac{1}{2}$, $\epsilon=0.002$.

Compute the following limits:

1. $\lim_{x\to 9} (x^2-9)/(\sqrt{x}-3)$

2. $\lim_{x\to -2} (x^3+8)/(x^2-4)$

3. $\lim_{h\to 0} 1/h((-3/(x+h)^2+3/x^2))$

4. $\lim_{h\to 0} 1/h(g(c+h)-g(c))$, where $g(x)=x^2+3x-c$.

5. Given a function f, and the numbers a and L, define $\lim_{x\to a} f(x)=L$.

6. Given a, L, ϵ, determine δ such that $|f(x)-L|<\epsilon$, for all x such that $|x-a|<\delta$. Draw a graph.

   $f(x)=2x+3$, $a=1$, $L=5$, $\epsilon=0.001$.

1. Given a, L, ϵ, determine δ such that $|f(x)-L|<\epsilon$, for all x such that $|x-a|<\delta$.

   $f(x)=x^2$, $a=-1$, $L=1$, $\epsilon=0.001$.

2. Define $\lim_{x \to a} f(x)=L$.

Compute the following limits:

3. $\lim_{x \to -1} (x^4-2x-3)/(x+1)$

4. $\lim_{x \to 2} (x^3-8)/(x-2)$

5. $\lim_{h \to 0} (1/h)(f(x+h)-f(x))$, where $f(x)=x^2$.

6. $\lim_{h \to 0} (1/h)(g(c+h)-g(c))$, where $g(x)=1/x$.

1. Suppose that $f(x) \to L_1$ as $x \to a$, and $f(x) \to L_2$ as $x \to a$. Prove that $L_1 = L_2$.

2. Given $\lim_{x \to a} f(x) = L_1$, $\lim_{x \to a} g(x) = L_2$, $\lim_{x \to a} h(x) = L_3$, state the theorems which justify the following statement:

   $$\lim_{x \to a} (f(x)+g(x))/h(x) = (L_1+L_2)/L_3.$$

Evaluate each of the following limits, giving the reason for each step by stating appropriate theorems:

3. $\lim_{x \to 3} (x^2-3x+5)$

4. $\lim_{h \to 0} (1/h)(\sqrt{x+h}-\sqrt{x})$

5. Compute $\lim_{x \to \infty} (x^2-2x+3)/(x^3+1)$

Evaluate the following limits, giving a reason for each step by stating the appropriate theorem:

1. $\lim_{x \to 2} (x^2-x-1)$

2. $\lim_{h \to 0} (1/h)(1/\sqrt{1+h}-1)$

3. Compute $\lim_{x \to \infty} (x^2+1)/(x+1)$

4. If $\lim_{x \to a} f(x)=L_1$, $\lim_{x \to a} g(x)=L_2$, prove that $\lim_{x \to a} (f(x)+g(x))=(L_1+L_2)$.

5. Given $\lim_{x \to a} f(x)=L_1$, $\lim_{x \to a} g(x)=L_2$, $\lim_{x \to a} h(x)=L_3$, $\lim_{x \to a} p(x)=L_4$, state the theorems which justify the following statement:

   $\lim_{x \to a} (f(x)g(x)-h(x))/(g(x)+p(x))=(L_1L_2-L_3)/(L_2+L_4)$, if $L_2+L_4 \neq 0$.

1. Compute $\lim_{x\to\infty} (\sqrt{x^2+2x}-x)$.

Evaluate the following limits, giving a reason for each step by citing the appropriate theorem:

2. $\lim_{x\to 1} (x+3)/(2x^2-6x+5)$

3. $\lim_{h\to 0} (1/h)(1/(x+h)-1/x)$

4. If $\lim_{x\to a} f(x)=L_1$, $\lim_{x\to a} g(x)=L_2$, prove that $\lim_{x\to a} (f(x)-g(x))=L_1+L_2$.

5. Given $\lim_{x\to a} f(x)=L_1$, $\lim_{x\to a} g(x)=L_2$, $\lim_{x\to a} h(x)=L_3$, $\lim_{x\to a} p(x)=L_4$, state the theorems which justify the following statement:

$$\lim_{x\to a} (f(x)-g(x))/(h(x)+p(x))=(L_1-L_2)/(L_3+L_4),\text{ if } L_3+L_4\neq 0.$$

In each problem a function is defined on a certain domain. State whether or not the function is continuous at all points in this domain. Sketch the graph.

1. $f(x)=1/(x+5),\ -7<x<5$

2. $f(x)=\begin{cases} 1/(x+7), & -10<x<-4,\ x\neq -7 \\ f(-7)=3 \end{cases}$

3. $f(x)=\begin{cases} (x^2-9)/(x^2-2x-3), & 0<x<5,\ x\neq 3 \\ f(3)=3/2 \end{cases}$

4. $f(x)=\begin{cases} (2x)/(x^2-4), & 0<x<2 \\ 3x-5, & 2\leq x\leq 5 \\ x^2+6, & 5<x<7 \end{cases}$

In each problem a function is defined on a certain domain. State whether or not the function is continuous at all points of this domain. Sketch th graph.

1. $f(x)=(x+2)/(x^2-3x-10)$, $3<x<4$

2. $f(x)=\begin{cases}(x+4)/(x^2-16), & -5<x<5,\ x\neq 4,-4\\ f(4)=2, & f(-4)=1/8\end{cases}$

3. $f(x)=(x^2-4)/(x^2+4)$, for all x

4. $f(x)=\begin{cases}x/3, & -\infty<x<2\\ x^2/6, & 2\leq x<\infty\end{cases}$

In each problem a function is defined on a certain domain. State whether or not the function is continuous at all points in this domain. Sketch the graph.

1. $f(x)=\begin{cases}(x^2-x-6)/(x-3), & \text{for all } x,\ x\neq 3\\ f(3)=5\end{cases}$

2. $f(x)=1/(x^2+2)$, $-7<x<5$

3. $f(x)=3+|x-2|/(x^2+1)$, for all x

4. $f(x)=\begin{cases}x^2-6, & -\infty<x<-1\\ -5, & -1\leq x\leq 10\\ x-15, & 10<x<\infty\end{cases}$

UNIT II

DIFFERENTIATION OF ALGEBRAIC FUNCTIONS AND APPLICATIONS

Algebraic functions are encountered very often in practice. In this unit, a set of differentiation formulas will be developed which will allow the derivative of every algebraic function to be found.

Objectives:

1) The student will be able to define the following terms or state the following theorems: sum formula, product and quotient formulas, chain rule, and higher order derivatives.

2) The student will state the above definitions and theorems with 70% accuracy.

3) The student will be able to solve a set of problems similar to those in the textbook with 70% accuracy.

Applications of the derivative:

Objectives:

4) The student will define the following terms or state the following theorems: tangent line, extremum of a function, rules for finding extremum and inflection points of a function, Rolle's Theorem, concave upward, concave downward, Mean Value Theorem, velocity, acceleration, and antiderivative.

5) The student will state the above terms and theorems with 70% accuracy.

6) The student will know how to solve related rate problems.

UNIT III

THE DEFINITE INTEGRAL AND APPLICATIONS

In this unit the other principle topic of the Calculus is introduced--the integral. Certain additional concepts are introduced in this unit to lay the foundation for the integral. The theory of integration is the most elegant found in Calculus.

<u>Objectives</u>:

1) The student will be able to state the following theorems, and define the following terms: upper bound, lower bound, upper and lower integrals, Theorem 1 (pp. 216), Theorem 2 (pp. 218), Theorems 3 and 4 (pp. 219), Theorems 5, 6, 7, and 8 (pp. 220-222), Fundamental Theorem of Calculus (both forms), definite integral, Mean Value Theorem, change of variable, sequences, Riemann integral, and Intermediate Value Theorem. 70% accuracy is expected.

2) The student will be able to solve problems similar to those assigned in the textbook, with 60% accuracy.

Applications of the integral:

<u>Objectives</u>:

3) The student will find the area in a region bounded by algebraic functions with 80% accuracy.

4) The student will find the volume of a solid formed by rotating algebraic functions about their axes with 50% accuracy.

5) The student will be able to find the area between two algebraic curves with 90% accuracy.

6) The student will learn how to calculate the distance traveled by a body with variable velocity.

7) The student will learn how to calculate the area of a surface of revolution, with 50% accuracy.

8) The student will learn how to calculate the work done by a variable force, with 80% accuracy.

9) The student will learn how to calculate the center of mass of a body, with 50% accuracy.

CONCLUSION AND RECOMMENDATIONS

The packaged program above provides the student with a complete list of concise objectives. This program should be distributed to the students on the first day of class so that they can know from the beginning what is expected of them. With program in hand, they are free to learn and progress at their own rate of speed. It should be noted that the first week of class time should be set aside simply to familiarize the students with the curriculum design. A guided tour of the video-tape facilities and any other classrooms or instructors' offices would serve very well to orient them to the system. Such an orientation procedure should be made manditory for all enrolled in Calculus; in fact, it might be constructive to make viewing the first video-taped lecture also manditory in order to "get the students' feet wet." The tours could be conducted by instructional aides or volunteers as well as faculty members themselves. Every effort should be made to ensure thorough acquaintance with the system before the actual study of mathematics begins. Another suggestion might be to design a quiz over the program to be taken at the end of the first week of classes. In this way students with problems can be quickly detected and assisted.

Of primary importance in this system is flexibility. The program as presented here gives the student three "chances" to pass a section examination, but this could be extended to four or even five chances. The characteristics of the student population and the characteristics of the math material itself should be considered.

Referring to the characteristics of the material itself, it is this variability which was taken into account by not completing the outlines of Units II and III. It can be reasonably assumed that the material on limits and continuity would be contained in any Calculus course offering. But the design of the units on the derivative and integral, especially applications would be dictated by what emphasis was placed on theory versus applications. For example, if this particular course were designed for math majors or physics majors, more stress would be placed on stating and proving theorems and acquiring an understanding of the basis of the mathematics presented. On the other hand, a first course for engineering or business majors would necessarily stress computational and manipulative ability, requiring only a passing acquaintance with the theory. Some topics such as surface integrals and center of mass might be deleted in a course for business majors, and a section on probability applications substituted. The program is designed with such adaptations in mind. Different textbooks would also reflect this.

For purposes of this paper, the texts of the videotaped lectures was not included. In any event, they should probably be from 20 to 30 minutes in length. A longer video lecture could become very tedious.

Finally, the fine details of such a program will surface only after its implementation. There will obviously be a need for minor changes, ie., the "bugs" will need to be ironed out. It should therefore be stressed to students and faculty alike that feedback of criticism is welcomed. A close communication link with students and faculty will serve to expedite the necessary changes and reformations.

Bibliography

Capper, Michael R. "Instructional Objectives for a Junior College Course in Calculus and Analytic Geometry." ERIC microfiche 033687, U.C.L.A., November, 1969.

Johnson, Stuart R. and Rita B. Johnson. Developing Individualized Instructional Material. Palo Alto, California: Westinghouse Learning House, 1970.

Mager, Robert. Preparing Instructional Objectives. Palo Alto, California Fearon Publishers, 1962.

Protter, Murray H. and Charles B. Morrey, Jr. Calculus with Analytic Geometry: A First Course. Palo Alto, California Addison-Wesley Publishing Company, 1967.

Thompson, Richard. Intermediate Algebra. Tucson, Arizona: University of Arizona Press, 1974.

Wright, Albert R. "Beyond Behavioral Objectives", Educational Technology, 33 (July, 1972), 9-14.