Procedure Allows Extensive Use of Calculus In Undergraduate Agriculture Economics Courses

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Introduction

The emphasis on technical skill development at colleges and universities has not excluded agricultural economics. Government, private industry and academic institutions have increased their expectations of quantitative and computer training acquired through a college undergraduate education. To satisfy these standards, students should be adept at these technical skills. This paper proposes a method by which the quantitative level of most junior-senior level agricultural economics courses can be increased while expanding student exposure to microcomputers.

Basic calculus (including simple differentiation) is developed in a workbook framework where concepts are developed, examples explained and students are asked to answer sample problems. This program is placed on a computer disk for students to use. Detailed instructions on how to operate the microcomputer and how to use this program should be given in the classroom.

Courses like production economics, farm management, marketing and price analysis, agricultural policy and international trade could utilize calculus in presentation of course material. Concepts such as elasticities, marginal cost, marginal revenue and marginal physical product can be derived mathematically.

In the next section, we discuss how computers have been used as teaching tools. Then, a description of the calculus workbook is given and some initial results and experiences are examined. The last two sections of this paper suggests ways to integrate the calculus workbook into undergraduate courses and summarizes our findings.

Computers As Instructional Tools

Computer use in the classroom is not a recent innovation [Babb and Eisgruber (1966)]. Since the mid-1960's, the PLATO system[1] has been used at colleges and universities to teach various classes [Chabay and Smith (1977)]. This computer assisted instruction technique incorporates high quality individualized instruction that allows student learning to be self-paced. A study by Paden et al. (1977) indicates that the PLATO system improves study habits, teaches students to highlight important concepts and adds pizzazz to classroom instruction.

Another computer assisted instruction method often used is the Teaching Information Processing System (TIPS). This technique was designed primarily to assist instruction in large classes [Kelly (1968)]. It was first used in economics classes and has been expanded to courses in the physical sciences, humanities and other social sciences. Henry and Ramsett (1978) and Kelley (1972) found TIPS to increase student achievement as measured by course examination scores.

The advent of the microprocessor has had a significant effect on computer usage and potential exists for even greater impact on classroom instruction. In agricultural economics, microcomputer capabilities are not limited to problem solving [McCarl et al. (1977); Erickson and Ellinger (1982)] and graphics [Debertin et al. (1977)] but have direct educational usage in extension and resident instruction.

Litzenberg (1982) mentions three reasons for the sudden interest in using computers in the agricultural economics profession. First, modern technology has enabled small computers to be available at "affordable" prices. Second, employers of agricultural economics students desire employees to have training in computer usage. Third, computer hardware and software have been specifically developed for classroom usage.

Description of Calculus Workbook and Initial Findings

The intent of this workbook is to introduce students to calculus. Presently, the workbook is designed for Apple computers with a minimum of 48 RAM K.[2] There are five sessions in the basic calculus workbook[3]:

Session 1: Preface and Instructions
Session 2: Introductory Mathematics
Session 3: Foundations of Calculus
Session 4: Basic Rules of Differentiation
Session 5: Sample Test.

The first session welcomes students to the workbook and provides instructions for its use. Introductory mathematics is reviewed in the second session, in terms of explaining the concept and use of variables and functions, and the distinction between discrete and continuous variables. The third chapter begins by illustrating the limit concept. Next, the notion of slope is explained in terms of limits. Finally, the derivative is introduced in terms of the limit concept and related to the slope of a line. The fourth session illustrates four basic rules of differentiation:

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constant function rule, power function rule, generalized power function rule and sum-difference rule. A sample multiple choice test is provided in the last session.

The strengths of this workbook are basically five-fold. First, the workbook provides individualized, self-paced learning. Second, the workbook provides "hands on" experience with microcomputers. Third, the workbook asks questions and then proceeds to answer them. Fourth, there are numerous graphical examples illustrating concepts such as slope and derivative. Fifth, a sample test is available for students to test their comprehension of basic calculus. There is immediate feedback from the sample test since answers are provided for each question.

The calculus workbook was used in two courses during the Spring 1984 semester at the University of Nevada, Reno. Upper division courses in Production Economics and Agricultural Economics Policy supplemented lectures on basic calculus with the calculus w assess students' mathematical backgrounds and their evaluation of the workbook. Results are summarized in Table 1.

Table 1: Survey and Calculus Test Results

Survey		
Number of students'	17	
Number of students with prior calculus background	7	
Number of students without prior calculus background	10	
Students' evaluation of calculus workbook:		
rated 1 if "no use"	0	
rated 2 if "little use"	1	
rated 3 if "useful"	5	
rated 4 if "quite useful"	6	
rated 5 if "extremely useful"	5	
Calculus Test Results		
Average test score	80.1%	(17)[2]
Average test score of students with prior calculus background	92.0%	(7)
Average test score of students without prior calculus background	71.7%	(10)
Average test score of students rating workbook ► 4	86.6%	(11)
Average test score of students rating workbook ◄ 4	68.0%	(6)
Average test score of students with prior calculus background and rating workbook ► 4	95.2%	(5)
Average test score of students without prior calculus background and rating workbook ► 4	79.5%	(6)
Average test score of students with prior calculus background and rating workbook ◄ 4	84.0%	(2)
Average test score of students without prior calculus background and rating workbook ◄ 4	60.0%	(4)

[1]The Production Economics course and Agricultural Economics Policy course had 9 and 13 undergraduate students respectively. Five students were enrolled in both classes. For these students, the two exam scores were averaged and they were asked to complete only one survey form.

[2]Figures shown in parentheses are number of students in each category.

Caution should be used in interpreting these results because of the small sample size. However, the results do provide interesting implications. First, students with prior calculus training did score higher than the average test score whereas students without prior calculus training scored lower than the average test score. Second, students who rated the workbook as either a 4 or 5 scored higher than the average test score, while, students rating the workbook as less than 4 scored below the average test score. Third, the average test score of students having prior calculus training and who rated the workbook as greater than or equal to 4 was higher than the average of all students with previous calculus training. Likewise, the average test score of students without prior calculus training and who rated the workbook as at least a 4 was higher than the average of all students without previous calculus training. Fourth, the average test score of students having prior calculus training and who rated the workbook as less than 4 was lower than the average of all students with previous calculus training. Also, the average test score of students without prior calculus training and who rated the workbook as less than 4 was lower than the average of all students without previous calculus training.

It is evident that prior exposure to basic calculus does improve test scores. This is perhaps true for any subject or topic — prior experience helps. However, more importantly, our results suggests that use of the calculus workbook does assist in increasing student achievement, as measured by higher test scores.

From the student perspective, we found that they enjoyed application of calculus to economic problems and principles. Our survey results showed fifteen out of seventeen students stating that they wished other junior-senior level agricultural economics courses would use basic calculus in course material. This perhaps suggests student appreciation of more quantitative applications in the undergraduate curriculum.

Incorporating the Calculus Workbook into the Undergraduate Curriculum

Several comments should be made about the calculus workbook and how it is integrated into classroom instruction. First, the workbook should supplement prepared lecture material on basic calculus. The instructor should not use the workbook as purely a substitute for lectures on calculus. The double dosage of lecture and workbook is aimed primarily at students who have not taken calculus previously and those who are not comfortable with mathematics. An important aspect that should be emphasized in class is not only discussing calculus concepts but also working calculus related problems. Homework assignments are very helpful to students.

Second, the sample test in Session 5 can be used as an indication of how successfully students are grasping concepts and solving problems. The computer program

can be set up so that each student's scope is recorded. This informs the instructor if certain concepts and/or problems are troublesome to students.

Last, the instructor should utilize concepts familiar to students (having already taken at least introductory agricultural economics or economics) as examples on how calculus can be used in agricultural economics. For instance in a production economics course, marginal physical products and output elasticities are useful calculus examples. In a marketing and/or prices course, price, income, and cross elasticities can be expressed and solved for by calculus. This should be done soon after completing lectures on calculus to reinforce these mathematical concepts.

The above comments apply especially for agricultural economics courses that do not require calculus as a prerequisite. For those agricultural economics courses that require calculus as a prerequisite, the amount of class time spent reviewing calculus can be reached. For these courses, assignment of completing the calculus workbook may be sufficient for reviewing basic calculus.

Summary

Our paper suggests a way to increase the quantitative skills of agricultural economics undergraduate majors. We propose utilizing a computer programmed calculus workbook as a supplemental instruction source. Our experiences suggest that the workbook reduces the amount of instruction necessary to adequately teach basic calculus, motivates students to use microcomputers and stimulates the learning process.

The workbook itself should not be viewed as a panacea. Each agricultural economics department has individual situations regarding mathematics requirement(s), program directions, course selection and availability, microcomputer accessibility, and other considerations. Regardless of the situation, the workbook and more broadly, the concept of computer assisted instruction serve as tools to enhance college curriculums.

The workbook concept can be easily extended for usage in other classes. For instance, the calculus workbook can be expanded and used in graduate courses. This would involve including more rules of differentiation, e.g., quotient rule, exponentials, etc. Also basic optimization procedures using the Lagrangean technique can be incorporated. Another example would be to develop workbooks for "hands on" use of linear programming and regression.

Notes

[1]PLATO is an acronym for "programmed logic for automated teaching operations."

[2]Conversion for IBM and IBM compatible usage is underway.

[3]Copies of the workbook are available upon request.

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Copyright Law Impact on Microcomputer Use

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Computer Software in Agriculture

As microcomputers continue to proliferate and become more important in agriculture, educators must understand copyright laws if they are to use software effectively and legally. Word processors, databases, spreadsheets and agricultural software are all used to provide students with practical computing experience. As a result, copyright laws effect which software packages are chosen for the classroom, and methods of copy protection create special problems in the classroom setting.

The issues surrounding copyrighted software have effected the computer industry for many years, but now members of the academic community must learn about these laws. Professors are presently facing these problems as they design databases and spreadsheet templates using commercially prepared software which is copyrighted. The problems presented by students copying software also require an understanding of copyright law. Moreover, as professors develop agriculture software a knowledge of copyright law and copy protection will help protect this software from unintended misuse.

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