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TEACHING COMPUTER TECHNOLOGY FOR AGRICULTURE USING PROGRAMMABLE CALCULATORS

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I. Introduction

The collection and manipulation of data to provide relevant information has become extremely important to decision makers in agriculture. The amount of data has proliferated and calculations have become more complex causing increased reliance on electronic data processing systems. Rapid development of computer technology has now literally placed the power of the computer in the hands of decision makers. Instead of working through computer specialists, operating managers find themselves able to call forth information directly from computers in order to make real time decisions.

While the elimination of time delay and reduction of human communication problems has improved timeliness and reliability of information available for decision making, there is a greater burden on decision makers in small and medium size agricultural firms. They now must understand not only the use of computerized information systems in decision making but also basic computer technology and have the skills necessary to operate equipment available to them.

This pervasive impact of cybernetics on the agricultural and as well non-agricultural economy presents a unique challenge to the educational community. In fact, the National Science Foundation stresses that due to the high potential for influencing the nation positively, teaching scientific students basic computer principles and concepts should receive high priority for use of educational resources over the next decade (National Science

Foundation, 1979). The Foundation concludes that development of appropriate educational programs is not only desirable, but inevitable and that federal funds and influence should be expended to accelerate the process.

The conclusions of the National Science Foundation on preparing students for a 'computerized world' were anticipated by agriculturists. In 1972, the course 'Computers in Agricultural Decisions' was introduced at The Ohio State University. Since its inception it has evolved in response to student needs and rapid technological advances.

II. Historical Perspective

Present computers operate thousands of times faster than the first models and at a fraction of the cost per unit of work accomplished. They are also easier to access; more accurate and reliable; simpler to program; less sensitive to environmental conditions; and occupy less space per unit of capacity.

Two developments of special significance to agriculture have been time-sharing and the advanced programmable calculator (hand computer). Time-sharing, in its broadest sense, allows one almost instant access to computer programs and data banks at any location from any location. All that is needed is a terminal, a telephone, electrical current, and a contract with the appropriate computer center. This development of the late 60s and early 70s was especially significant to agriculture as it allowed typically small agricultural firms (farm and non-farm) and the various State Cooperative Extension Services to access computer technology at various locations at relatively low cost.

Battery powered hand held calculators first became available in the early 1970s. This technology has been developed to the point that programmable calculators are sophisticated computers. Many of the programs previously available through time-sharing are now available on programmable calculators. These units provide access to computer capability at very low cost. An advanced programmable calculator can be purchased for about $200.00, a compatable printer for about $150.00, and an agricultural exchangeable module for about $40.00, for a total outlay of about $400.00. Costs of operation are negligible.

The future will see more miniaturization of hand held units. Some experts believe that VLSI (Very Large Scale Integration) will make it possible, perhaps within five years, to compress the number-handling proficiency of a modern, large computer into a single part about the size of a match head. The advent of such 'superchips' could prove to be the technological equivalent of the leap from transistors to integrated circuits in the early 1960s. (Shaffer, 1979).

III. Educational Objectives

'Computers in Agricultural Decisions' at The Ohio State University is a first course in applied computer techniques. The overall objective of the course is to develop in students the ability to solve agricultural decision making problems with the help of computer systems. The problem solving approach is taught as a four step sequence - 1) problem analysis, 2) flowchart application, 3) coding and executing the program, and 4) documentation.

The specific educational objective in problem analysis is for students to demonstrate an understanding of the role computer systems can play in the recognition of a problem, identifying the cause of the problem, and analyzing alternative solutions. Emphasis is placed on the design of feasible management information systems.

A second educational objective is to develop the ability to use program and system flowcharting techniques in problem solving. Students use the four major flowcharting techniques--initialization, looping, developing a sum, and developing a counter to formulate a graphic representation of operations and decision logic required to solve problems in their particular agricultural specialties.

A major portion of the course is devoted to the third step in problem solving--coding and executing the program. The specific educational objective here is for students to demonstrate a working knowledge of software elements and hardware components that make up computer systems. Studying computer number systems, languages, and programming contribute to the objective. Comparison of design characteristics and capabilities of various computers (e.g. main frame systems, time-sharing, mini-computers, and hand held units) also aids students in reaching this specific educational objective. As they organize information for decision making, students come to recognize the importance of documentation, the fourth and final step in problem solving.

IV. Characteristics of Advanced Programmable Calculators Enabling Students to Meet Educational Objectives

Recent development of advanced programmable calculators held promise as a means to help meet educational objectives. New models are programmable, allow preservation of programs and data on read/write media, have solid state exchangeable program modules, allow upward compatibility in both learning and new hardware introduction, are low cost, portable, and offer versatility in usage. The unit purchased for use in the course was the Texas Instruments model 59. Models with similar capabilities are available from other manufacturers.

Programmability is the most attractive feature of these units. Fairly sophisticated programs can be developed and executed. Because the units can be programmed, students using a TI-59 or similar programmable calculator can write, code, and execute programs. The graphic representation of the problem to be solved, i.e. the flowchart, takes on new meaning when program steps and data are entered into the unit. Execution provides immediate feedback to students. Applications requiring numerous calculations can be handled with little difficulty. However, the small memory compared to more sophisticated computer systems does place an upward limit on the number of programming steps and the amount of data that can be entered.

Late model programmable calculators allow users to save programs and the contents of memory registers on read/write media, magnetic cards in the case of the TI-59. This means users can save for future use an unlimited number of programs. To solve a particular problem, a user loads a program into the hand computer simply by having the unit read magnetic cards. Data may be entered by hand or from magnetic cards.

Commonly used programs are often available on modules, each containing about 25 programs. These programs or portions of them can be used individually in program solving and can also be used as 'subroutines' in individually written programs. This subroutine capability greatly increases the potential scope of user written programs.

Concepts and skills learned and developed by students in working with hand computers ease the transition to mini-computers, timesharing, and mainframe units. For example, in using the programmable calculator, students must assign locations for both instructions and data and make provisions for recall from assigned locations. This requirement, which in a large computer is automatically handled by a compiler, makes them more aware of basic computer operations.

Manufacturers will maintain upward compatibility in new models with hand held computers of the future utilizing many of the features of present models, for example key layout. Students becoming proficient in the use of present models should find little difficulty in upgrading to newer, more powerful equipment.

Educators are constantly reminded of budget limitations. Compared to other automatic data processing equipment, the cost of providing 'hands-on experience' with programmable calculators is very low. Cost comparisons will be made in a later section.

Providing students with what amounts to their own personal computer adds greatly to their satisfaction with the course. Portability of the units means they can be used in the classroom and can even be checked out of the library on demand by students. For example, the TI-59 weighs less than a pound and can operate for about three hours on a battery charge.

Versatility of programmable calculators also adds satisfaction by enabling students to acquire knowledge from a pre-existing base. A programmable calculator can be used by students simply as a calculator or as a computer using internal programs contained in exchangeable modules, programs developed by other agriculturists which are entered by coding, and programs written by students themselves. This progression on the machine from use as a calculator to self programming can ease student transition into the sometimes intimidating world of computers.

V. Availability of Programs for Programmable Calculators

An important factor in any computer system is availability of appropriate programs for use in solving problems. Fortunately, development of programmable calculator programs for agricultural applications has been rapid. Many programs written for other computer systems were easily adaptable to the compact units. Agricultural extension specialists at Iowa State University led the way in this conversion and in the development of new programs. They started a subscription service whereby users can obtain a large number of current programs and also obtain new programs as they are released (Iowa State, 1978). Agricultural extension specialists at Cornell University have also developed programs that are available through the Northeast Regional Agricultural Engineering

Service on a subscription basis (Northeast Regional Agricultural Engineering Service, 1978).

When Texas Instruments became aware of the widespread use of the TI-59 by agriculturalists they commissioned Iowa State University to refine sixteen of the most commonly used agricultural programs for inclusion in an exchangeable agricultural module (McGrann, 1979). The module is now available commercially along with ten other exchangeable modules (master library, applied statistics, real estate and investment, aviation, marine navigation, surveying, leisure library, securities analysis, business decisions, and custom library information) which offer users a wide range of programs in many different subject matter areas.

In addition to the modules, Texas Instruments offers specialty packettes which are collections of programs designed for special interest groups that the user keys into the calculator. Finally, one can join user groups wherein an individual may both contribute and receive programs.

VI. Anatomy of the Course

Enrollment is limited to 86 students each quarter with student demand exceeding capacity most quarters. All students meet together three periods per week for lecture. The class is then divided into four groups, based on subject matter interest, for discussion/laboratory periods. Sections include horticulture, animal industries, crop production, and agricultural business. Each group is restricted to 22 students and meets once a week for a two hour period. Students are required to purchase two texts for the course. The first, Introduction to the Computer: The Tool of Business is used to introduce them to basic computer concepts (Fuori, 1977). The second, Programmable Calculators: Business Applications is specific to the equipment being used (Aronofsky, 1978).

Experience has shown that an ideal complement of equipment for the course is 15 programmable calculators with an agricultural module for each and 10 compatible printers. This allows one calculator for each two students in the discussion/laboratory sections, one for the instructor, and three spares to handle unusually large sections and to replace units being repaired. McGrann and Edwards, in their extension experience, also found one calculator for each two participants in workshops to be ideal (McGrann, 1979). The major utility of printers is in writing and debugging programs. When the equipment is not being used in discussion/laboratory sessions, it is made available to students through the Agriculture Library's closed reserve system. Students are able to check out a 'computer packet' (Table 1) anytime the library is open and units are available. Use is restricted to the library.

A term paper of ten to twenty pages plus an oral presentation of the paper is required of each student. Students may choose any topic, broad or narrow, that relates concepts and techniques taught in the course to their personal area of interest. Most students use existing programs or write special programs for the programmable calculator as a portion of their term projects.

Each student is allocated ten minutes in a special interest discussion/laboratory section to present a summary of the term paper.

For discussion purposes, the course sequence can be divided into three parts 1) introduction to programmable calculators, programming, problem solving, and automatic data processing; 2) computer languages and more advanced programming; 3) basic computer principles.

The equipment and its operation effectively attracts the students' attention. To take advantage of this, students are introduced to the programmable calculator in the first discussion/laboratory section. In a workshop setting students are asked to store values in memory registers, perform mathematical calculations recalling specific values from appropriate registers, and then accumulate results in still other memory registers. This approach gives students a taste of data processing, introduces them to the equipment, and builds rapport between the instructor and students as well as among students.

Next, students learn simple programming on the programmable calculators. Students learn that a program is simply a method of getting the equipment to do the work of pressing buttons and writing down intermediate results rather than humans doing it. In the discussion/laboratory periods, the assignment is to write a simple program to do the same mathematics done manually the previous week.

Students then learn to use magnetic cards to store programs and data off-line and to use the printer. After writing and debugging programs without these accessories, students appreciate their contribution. With this background they are introduced to flowcharting in modeling as an approach to problem definition and analysis. The previous work with the programmable calculator serves as a bridge to relate flowcharting symbols to identifiable programming steps.

The middle third of the course concentrates on programming and applied problem solving. During this time students are first introduced to the general framework of computer languages. Next, they learn more sophisticated programming which includes internal decision making through maintaining a counter, branching, and looping. They are also introduced to the BASIC language by using time-sharing. This demonstrates the similarities and differences between machine specific and high level computer languages. Discussion/laboratory sections are devoted to application problem solving and one major assignment wherein each student writes a fairly sophisticated program on the calculator, using the techniques learned, to solve an agricultural problem.

The final third of the quarter is spent learning basic computer principles. After students become proficient operators and problem solvers using programmable calculators, they seem to have little trouble transfering similar procedures to more sophisticated equipment. In this section, students are introduced to computer number systems, the history of computers, processing and storage devices, input/output media and devices, advanced computer concepts and anticipated future developments. Discussion/

laboratory sections are devoted to programming in BASIC and to oral presentations by students of term projects.

VII. Ohio State Experience

The need to educate agricultural students in computer technology and its application to agriculture was recognized at Ohio State at the beginning of the decade. A course was taught on an experimental basis during Winter Quarters 1972 and 1973. It was officially introduced as 'Computers in Agricultural Decisions', Autumn Quarter 1973. Since then it has been taught each Autumn, Winter, and Spring Quarter. Students were granted the option of using credit hours earned from the course to help meet basic College of Agriculture requirements in the category of mathematics, computer science, statistics, or accounting. Allowing students to count 'Computers in Agricultural Decisions' toward the 'math' option has contributed to a very heterogenous class composition (Table 2). Even with heterogeneity there was little difference in class performance according to class rank (Table 3). The percent of freshmen dropping the course was higher than for the other classes, which probably contributed to the group's higher grade point average.

Numerous changes have been made since inception of the course. It was changed from three to five credits starting Autumn Quarter 1975. Autumn 1977, the course format was changed from all lectures to three periods of lecture per week plus one two hour discussion/ laboratory session. While this was an improvement, the change was not as effective as hoped. The heterogeneity of student interest reduced the effectiveness of laboratory demonstrations. For example, animal science students could not or would not relate to the demonstration of a horticulture computer program and vice versa. This situation was rectified by making the discussion/ laboratory sections subject matter oriented beginning Spring Quarter 1978.

Changes have also occurred in the means by which students are provided 'hands-on experience' with computer equipment. Providing this experience to students in a problem solving atmosphere has been a goal since the introduction of the course. Due to budgetary limitations and access difficulties with both hardware and suitable software on the in-house university computer system, the demonstration approach was used. A portable terminal was brought into the classroom to access agriculturally oriented computer programs on various computer systems (i.e. Telplan, CMS, Com-Share, Ohio State, etc.) on a time-sharing basis. While this approach was useful, it fell far short of the goal of offering practically unlimited individual student access to appropriate hardware and suitable problem solving software. Advanced programmable calculators, first used Winter Quarter 1979, have provided a means of reaching this goal.

Utilizing programmable calculators provided students with virtually unlimited 'hands-on experience' at extremely low cost. During Spring Quarter 1979, students averaged 31 hours each of computing time outside the classroom by checking the computer packets out of library closed reserve. The only loss of equipment was one five dollar battery charger. Table 4 shows the investment and depreciation, repairs, and replacement charges for the equipment. A five year life length was estimated due to unlimited student access and obsolescence. Additional overhead items such as library costs, and electricity are not included. Quarterly costs for equipment can be budgeted at about $700.00 (Table 5). Based on time of 36 hours per student, the direct cost per hour was less than twenty-five cents.

To get a better measurement of student reaction to the programmable calculator and the course as it is now taught, students were asked to complete a questionnaire during the last week of Spring Quarter 1979. All but three of the 68 students completed evaluations. Students were enthusiastic about the use of the programmable calculator. Ninety-five percent rated it as either essential, very important, or important when asked "How important was access to and utilization of the TI-59 to your comprehension of computers and their present and future utilization in agriculture and society?" The remaining five percent rated it as slightly important. No one rated it as not important. Eighty-four percent of all students ranked it in the top five when asked "Compared to all other courses you have taken at Ohio State, how would you rank 'Computers in Agricultural Decisions' as to its utility in preparing you for your future?" This figure ranged from 100 percent for freshmen to 75 percent for seniors (Table 6). Students also found the course demanding. When asked "Compared to all other courses you have taken at Ohio State how would you rank 'Computers in Agricultural Decisions' as to the amount of effort required to meet course objectives?" eighty-six percent ranked it in the top six. Students reported spending an average of 59 hours outside of the classroom on the course with very little difference noted for class rank. A little over half of the outside time was spent operating the calculators (Table 3).

VIII. Summary and Recommendations

Rapid advancement of cybernetic technology has presented a unique challenge to educators. First, the technology has become pervasive, effecting all aspects of the economy. For students, both agriculture and non-agriculture, to be adequately prepared to function effectively in the 'computerized world' of the present and future they need a basic education in the principles and concepts of computers and related information technology. They also need to know how to apply it in their particular areas of specialization. Secondly, the technology has provided a means of achieving this education at relatively low cost.

Recognizing the educational need regarding cybernetic technology, the Ohio State University created the course 'Computers in Agricultural Decisions' which was first taught in 1972. Students are allowed to use the course to help meet basic College of Agriculture requirements in the category of mathematics, computer science, statistics, or accounting. The course has evolved based on student needs and advancing cybernetic technology. Presently it is taught using a combination of lectures and subject matter oriented discussion/laboratory sections. Students have consistently rated the course as having high utility in preparing them for the future.

Recent developments in programmable calculator technology added a needed dimension to the course. The units allow low cost, almost unlimited, 'hands-on experience' with both computer hardware and software. Programmable calculators provide an excellent tool for teaching basic computer concepts and applications to agriculture. Students can write programs to fit specific applications or use programs already developed. As it is now taught using programmable calculators, 'Computers in Agricultural Decisions' gives students knowledge and skills which can serve them well in research, extension, teaching or agribusiness.

Based on The Ohio State University experience, the following recommendations to educators contemplating a similar course are offered by the authors. First, if class composition is heterogeneous, create subject matter oriented discussion/laboratory sections each limited to 25 students. Small subject matter groups create good rapport between instructor and students and also among students. They also aid learning by allowing students more time to concentrate on areas of specialization. Second, provide adequate equipment for almost unlimited 'hands-on experience'. This can be accomplished at relatively low cost by using programmable calculators. Third, anticipate and prepare for increased demand for the course. As the need for this type of education is felt by students and educators in the various agricultural disciplines, demand will increase for the course and for additional subject matter discussion/laboratory sections.

References:

Aronofsky, Julius S. Robert J. Frame and Elbert B. Greynolds Jr., Programmable Calculators-Business Applications. New York, NY: McGraw-Hill Book Company, 1978.

Fuori, William M. Introduction to the Computer-The Tool of Business. Second Edition, Englewood Cliffs, NJ: Prentice-Hall, Inc., 1977.

Iowa State University Cooperative Extension Service. Programmable Calculator-Programs Applied to Agricultural Decisions. Ames, IA: Iowa State University, 1978.

McGrann, James M., and William M. Edwards. "Application of the Programmable Calculator to Extension Agricultural Management Programs: Experience from Iowa." North Central Journal of Agricultural Economics 1 (1979): 147-153.

National Science Foundation, Technology in Science Education: The Next Ten Years, Perspectives and Recommendations. Washington, 1979.

Northeast Regional Agricultural Engineering Service. Calculator Programs for Extension. Ithaca, NY: Cornell University, 1978.

Shaffer, Richard A., "The Superchip-Vast Computing Power is Seen as More Circuits Squeeze on a Tiny Part." The Wall Street Journal, LIX, No. 136. Apr. 27, 1979.

Texas Instruments, Incorporated. Programmable TI-58/59-Solid State Software Libraries and Other Accessories. Lubbock, TX: Texas Instruments, Incorporated, 1977.

Table 1. Materials Included in Library Check Out Packet

Expandable Folder (4½ x 14 3/4 x 3½ - four pocket)
Programmable Calculator (Texas Instruments TI-59)
AC adapter/charger 120 Vac
Master Library Book with Module
Agricultural Library Book with Module
Personal Programming Book provided by The Equipment Manufacturer
Programmable TI 58/59 Solid State Software Libraries and Other Accessories Booklet

Table 2. Selected Characteristics of 68 Students Completing 'Computers in Agricultural Decisions', Spring Quarter 1979.

Class Rank	Percent
Seniors	30
Juniors	32
Sophomores	26
Freshmen	12

Major	Percent
Animal Science	30
Agricultural Economics	29
Horticulture	16
Agricultural Education	10
Dairy Science	4
Agronomy	4
Agricultural Communications	3
Poultry Science	2
Agricultural Mechanization and Systems	2

Sex	Percent
Male	68
Female	32

Table 3. Average Grade Point and Reported Nonclassroom Student Time Expended on the Course.

Item	Total	Class Rank			
		Freshmen	Sophomores	Juniors	Seniors
Number of Students Reporting	65	8	17	20	20
Average Grade Point[a]	2.8	3.0	2.8	2.7	2.8
Average Total Hours Expended Outside the Classroom	59	58	53	63	59
Average Hours Expended Outside the Classroom Operating the Programmable Calculators	31	22	31	36	32

a/ Based on a four point system (A=4, B=3, C=2, D=1, E=0).

Table 4. Capital Investment for Data Processing Equipment and Costs for Depreciation, Repairs, and Replacement.

Item	Cost[a]	Life Length	Yearly Depreciation[b]	Yearly Repairs and Replacement[c]
	dollars	years	dollars	dollars
Programmable calculators (Texas Instruments-TI-59) 15 @ $204.00	3060.00	5	612.00	459.00
Printers (Texas Instruments-PC-100C) 10 @ $148.00	1480.00	5	296.00	222.00
Agricultural module (Texas Instruments/ Iowa State) 15 @ $37.50	562.50	5	112.50	84.37
Extension Cords	50.00	5	10.00	7.50
TOTAL	5152.50		1030.50	772.87

[a]Actual 1979 costs.

[b]Zero salvage value.

[c]15% per year.

Table 5. Annual Costs, Costs per Student Hour Taught, and Costs per Hour of 'Hands on Experience'.

Item	Annual Cost	Cost per Student Hour Taught[a]	Cost per Hour of 'Hands on Experience'[b]
Fixed Costs			
Depreciation	$1030.50	$0.81	$0.11
Repairs and replacement	772.87	0.61	0.08
Variable Costs			
Printer paper 36 rolls @ $3.40	122.40	0.10	0.01
Expandable Folders 45 @ $3.00	135.00	0.11	0.01
TOTAL	$2060.77	$1.63	$0.21

[a] 85 Students x 5 hours x 3 quarters = 1275 hours.

[b] Estimated at 9180 hours per year or 36 hours per student.

Table 6. Student Response by Class Rank to the Question "Compared to All Other Courses You Have Taken at Ohio State How Would You Rank 'Computers in Agricultural Decisions' as to Its Utility in Preparing You For Your Future".

Rank	Overall	Class Rank			
		Freshmen	Sophomores	Juniors	Seniors
	percent				
First	15 (15)[a]	25 (25)	23 (23)	10 (10)	5 (05)
Second	17 (32)	25 (50)	23 (46)	20 (30)	10 (15)
Third	17 (49)	50 (100)	12 (58)	15 (45)	10 (25)
Fourth	23 (72)	0 (100)	18 (76)	35 (80)	25 (50)
Fifth	12 (84)	0 (100)	6 (82)	10 (90)	25 (75)
Less Than Fifth	16 (100)	0 (100)	18 (100)	10 (100)	25 (100)

[a]Percentages are accumulated in parentheses.