Application of the Programmable Calculator to Extension Agricultural Management Programs

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Extension economists have long struggled with making recommendations to farmers on the basis of "rules of thumbs," which may become obsolete or are not universally applicable, versus encouraging detailed numerical analysis, which, while providing more precise and individualized answers, often involves laborious and difficult calculations as well. Fortunately, the development of computers and electronic data processing has added a new dimension to decision making in agriculture.

A recent addition to the set of tools available to perform high speed numerical analysis is the programmable calculator. This hand-held machine can perform all the normal functions of a small calculator. It can also store a number of variables in memory and recall them for use in prewritten programs and subprograms which can be activated by pressing one of several designated keys. When used with the optional printing hardware, not only can answers be labeled and printed for a permanent record, but the calculator can also be programmed to print questions that will prompt the user to supply desired facts. Once a program is entered into the calculator, it can be permanently recorded by passing a magnetic card through a slot in the calculator. The program can be reentered into the calculator at any time by simply inserting the card through the same slot.

Several manufacturers build programmable calculators. At present, memory capacity ranges up to 100 values and nearly 1,000 programming steps. However, rapid advances in capacity and capabilities have been made in recent years and probably will continue. Some models, such as

the Texas Instruments TI-58 and TI-59, also have an internal solid-state module library that contains permanently stored programs that can be accessed directly from the keyboard.

Development of Computerized Management Aids

Computer programs for extension activities have been available for a number of years. Early efforts centered on large models processed in a batch system. One common example was the application of linear programming routines for farm enterprise selection [1]. Operational problems in transferring data from the client to the computer (usually located on a university campus) and back were somewhat alleviated by the introduction of remote terminals which transmit data to and from the central computer via telephone [2]. A number of states now have systems available for utilizing computer management aids through remote time-sharing terminals [5]. A recent study in New York state by LaDue that compared alternative remote access systems has indicated that these systems have a positive impact on extension programs. LaDue points out that the systems allow extension agents to handle management problems more quickly and accurately. Easy access and instant turnaround are important for making timely decisions. Use of such a tool may create a whole new type of service to be offered by local extension staff [5].

The next logical step in hardware development has been to put computing capability in the hands of the clientele. One proposal has been to put remote terminals in farm offices. Another alternative is the "micro-computer," one of the fastest selling consumer items in existence today. The micro-computer can free the farmer from dependence on telephone connections, as well as, extension agents for

routine analyses. To date their adoption has been limited primarily by a lack of available software [3].

The Programmable Calculator

The programmable calculator offers many of the same advantage as a micro-computer only in a cheaper and simpler package. While it cannot completely replace other types of computerized management aids, the experience of the authors has been that it is readily accepted and utilized as a decision tool by farmers and agribusinessmen.

Advantages

The programmable calculator offers some special features relative to other types of hardware: (a) a useful amount of analytical capacity can be obtained at a low cost both for hardware (under $250 in some cases) and software; (b) they are compact and portable; (c) they are similar in appearance to common hand-held calculators; presentation of programming capacity in a familiar package removes psychological barriers about operation of computers; (d) instant turnaround and problem rerun or interaction is possible; (e) the user can operate the calculator in privacy when it is timely and convenient, and with necessary sources of data such as farm records close at hand; and (f) its programming ease relative to larger computers allows some users to modify programs to fit their particular decision environment, or to write their own programs (see survey results discussed later).

An important advantage to extension workers is that the principles used in making certain management decisions can be taught at the same time as the use of the calculator is demonstrated. In addition, the ease with which the hardware and the ability to use it can be acquired

by the client frees the extension agent from the need to perform "personal service" through repeated use of the programs with the same individual.

As farmers and extension workers use the programmable calculator, especially if they write their own programs, their understanding of the uses and limitations of calculators and computers change. They no longer hold the machines in awe, but instead begin to question the logic of the programs. This change in attitude should lead to quicker and more effective utilization of the full spectrum of electronic decision aids.

It is true that many of these advantages apply to micro-computers as well. However, the lower cost and greater simplicity of programmable calculators should make their adoption feasible for a much greater number of farm operators, and helps avoid "large-operator bias" in the technology offered in extension programs. In addition, extension personnel themselves are more easily convinced of the usefulness of electronic decision aids where their adoption requires relatively little staff training or commitment of funds.

Limitations

Compared with the large central computer or micro-computers, programmable calculators have limited data storage capacity and cannot adequately record large quantities of information for later retrieval. Thus, their potential for farm record keeping is not great. Calculating capacity also is limited. The programmable calculator is most useful for analyzing a single farm enterprise or making marginal management decisions. It has less capability for performing large-scale simulations or optimizations involving whole farm models or complex systems

interactions. That is, it is suited more to day-to-day decision making than to reorganization of the farm business. As Hinton suggests the user should consider the type of problem which will be most commonly solved in choosing among hardware alternatives [4].

An individual using the programmable calculator on his own does not have the benefit of continued contact with a field agent to assist him in program selection or interpretation of results. Likewise, the capacity of the printer does not allow extensive explanation and formatting of output. This requires greater documentation of programs and supportive materials such as work sheets and manuals. The quantity of information which can be inputted and outputted is also limited. However, this also reduces the temptation to ask the user for more data than he can reasonably be expected to supply, or to provide him with more numbers than he can easily absorb. Lastly, program use cannot be centrally controlled or monitored. Program revisions can be made only by issuing error sheets or new programs.

Development of Software

The Iowa State University Cooperative Extension Service, after evaluating the programmable calculator's potential, initiated a multi-disciplinary effort to develop software for agricultural decisions. Originally, programs were intended for use by extension personnel, but it soon became evident that farmers and agribusinessmen were acquiring programmable calculators of their own even after very limited exposure to them in extension programs, and requesting programs.

The extension staff at the state and area level, farm business association consultants, and several farmers have assisted in identifying

areas of software needs, writing programs, and field testing the programs. The first programs were concentrated in the areas of livestock nutrition and ration formulation, livestock enterprise budgeting and break-even analysis, grain marketing, land purchase analysis, machinery economics, income tax estimation, farm loan analysis, and depreciation methods. Since then the list has been expanded to include measurement of crop yields and harvest losses, evaluating fertilizer sources, livestock performance indexes, capital budgeting, farm record analysis, and evaluation of feed-grain program alternatives.

In the beginning, programs were written to perform calculations in the same sequence as they appeared on several budgeting work sheets that had already been developed for extension use. This, in turn, led to the development of new materials. For example, after programs were written for cattle feeding and feeder pig work sheets, similar programs were written and work sheets published for lamb feeding, feeder calf, feeder lamb, feeder pig, and farrow-to-finish swine production. Both program development and the need to standardize procedures for writing and distributing programs led to a greater degree of interdisciplinary cooperation among campus-based extension specialists.

Each program description has a format that includes a statement of the objective of the program, an explanation of the type of problem that can be analyzed, a list of the necessary data to input, the procedure for obtaining outputs, and an example problem. Program descriptions also include formulas and (or) work sheets so users can see how the program was developed. A listing of the program steps that can be recorded for permanent use on a magnetic card also is included. The

magnetic cards themselves are not distributed because cards recorded with one calculator cannot always be read by another calculator, even of the same model.

After a number of programs were developed and field tested, they were made available through a subscription library [6]. Subscribers receive new programs as they are made available. Interested potential users were informed about the programmable calculator through the farm press, during specialized farmer and agribusiness meetings where it was used to illustrate examples of technical problems, and through extension meetings concerned specificially with its use. At present more than 1,300 libraries have been distributed in 40 states and 12 foreign countries.

In addition, a number of the more popular programs were incorporated into a small plastic chip or module which can be inserted into the Texas Instruments TI-58 or TI-59 calculators. This eliminates the need for magnetic cards, but does not allow modification of programs. To date, over 600 agricultural modules have been distributed.

Evaluation of the Subscription Library

A survey was conducted 6 months after the program subscription library was released to identify: (a) characteristics of the users of the library, (b) most frequently used programs, (c) problems encountered in using the programs, and (d) areas of interest for future program development.

Of the 300 subscribers existing at that time, 140 returned usable questionnaires.

Characteristics of Users

The programmable calculator programs have been popular with people who work with farmers as well as with farmers themselves. Of the respondents to the survey, 28 percent were farmers, 64 percent non-farmers, and 8 percent were involved in both nonfarm and farming activities (see Table 1).

Table 1. Occupation of programmable calculator library subscribers.

Occupation	Number [a]	Percent [a]
Farmer	50	36%
Buy or sell agricultural products or inputs	21	15%
Provide services of credit to farmers	15	11%
Iowa State University faculty or Extension	15	11%
Non-ISU Agricultural educator	27	19%
Other	22	16%

[a]Ten respondents reported having a nonfarm occupation as well as being a farmer.

The nonfarmer respondents most often described their occupations as agricultural educators not from Iowa State University (26 percent), buyers and sellers of agricultural products and inputs (21 percent), Iowa State University faculty or Extension staff (15 percent), or providers of services or credit to farmers (15 percent). These groups accounted for 77 percent of the nonfarmer respondents and 55 percent of all respondents.

Most of these people serve numerous clientele. This means that the number of farmers and agribusinessmen who have benefited from the programs is considerably greater than the number who have actually purchased the libraries.

The first programmable calculator programs were written for use

with the Texas Instruments SR-52 (since discontinued) and Texas Instruments TI-59 calculators. Many of the programs can also be used with the Texas Instruments TI-58 model, which has less memory capacity and lacks the facility to use magnetic program cards, but will accept the pre-programmed module.

A number of sources have been used to inform potential users of the programmable calculator library developed by Iowa State University, as shown in Table 2. Forty-four percent of the respondents reported that they first learned about the program library by attendance at an extension meeting or through contact with extension personnel. Farm magazines, newspapers or radio were the next popular sources of information (32 percent). The farm magazine coverage of the programmable calculator and library has been quite extensive.

Table 2. Source of first information about programmable calculator programs.

Source	Number	Percent
Farm magazine, newspaper or radio	45	32%
Extension meeting or employee	62	44%
Friend, lender, consultant, etc.	11	8%
Other sources	22	16%
Total	140	100%

At the time of the survey, 26 programs had been distributed.

Probably because of the short time for which the library had been available and the degree of specialization of many of the programs, the average respondent had used only five of the programs available. Seventy-five percent of the respondents indicated they had used less than eight of the programs, and a third had used only two or less. The number of programs used increased with the length of time the subscriber had possessed the library. The educational effort to teach users how to use the programs had been very limited at the time survey was taken. As Walker suggests no matter how well the programs are designed and documented, extensive use is unlikely without a parallel educational effort [8].

Respondents were asked to indicate whether each program used was very useful, of some use, or of little use. The following types of programs were identified as being most useful: (1) budgeting work sheets to estimate profitability and break-even prices for feeder cattle and feeder pigs, (2) ration analysis for feedlot cattle and swine, and (3) financial analysis of a land purchase decision.

All programs were indicated to be useful to at least some of the respondents, as well as of very little use to others. This is, of course, a reflection of the varied occupations of the respondents.

Operational Problems

Sixty-four percent of the respondents reported some problems in using the calculators and libraries, at least initially. Types of problems encountered are shown in Table 3 on page 11.

Table 3. Problems encountered in using and recording programs.

Type of Problem	Number[a]	Percent[a]
No problems encountered	50	36%
Mechanical problems with the calculator, charger or printer	18	13%
Incorrect results from program after entering all steps	13	9%
Problems recording program steps on the magnetic cards and/or reading recorded cards into the calculator	42	30%
Problems interpreting what information is to be entered or stored in the calculator	15	11%
Problems interpreting the significance of answers obtained with the program	15	11%

[a] Some respondents indicated more than one type of problem.

The most frequent problem identified was correctly using the magnetic program cards. Difficulties were encountered in recording a program on the calculator, recording the steps on the magnetic cards or reading the cards into the calculator by 30 percent of the respondents. Some of these problems could be traced to mechanical failure of the calculators themselves. Eleven percent indicated they experienced some problems in interpreting what information was necessary to enter or store in the calculator to use the program, and the same percentage reported problems in interpreting the significance of answers obtained with the program.

Having a printer for the calculator did tend to reduce the problems respondents had in recording and using the programs, especially in entering program steps and recording them on the magnetic tapes.

Forty-four percent of the respondents indicated that they had written programs for their own use, or had modified programs received from Iowa State University. Respondents writing their own programs also had significantly less problems in recording and using the library program than those who did not. Users who had the time and ability to learn to program may have had more aptitude for using the calculator in the first place. Programming in itself requires knowledge of the skills needed for entering and recording prewritten programs.

Subscribers had written programs for such purposes as analyzing costs of motor vehicles, calibrating sprayers, placement of grain bins and augers, fertilizer cost comparison, and making simple bookkeeping transactions.

Experience has shown that a 2-3 hour training session is usually sufficient to overcome problems in operating the calculators. In this amount of time, people who have not used a programmable calculator previously are usually able to learn to use and record prewritten programs. It is important, however, that groups not be too large for effective instruction. A maximum of 10-12 persons per instructor, with at least one calculator for every two people, is recommended.

Sixty-nine percent of the respondents indicated that having the library programs stored internally in the calculator, such as with the program modules, would help eliminate some of the problems they encountered in using the library. This is consistent with the respondents' indication that recording program steps on the magnetic cards and (or) reading the cards were their primary problems in using the library. It is hoped that the availability of the Texas Instruments - Iowa State University agricultural module will reduce problems in this area.

Areas for Future Program Development

Respondents were asked to indicate for what types of additional problems they would like to see programs developed. The survey showed that the respondents would like to see programmable calculator programs developed in each of several areas. Capital investment analysis, marketing and farm record analysis were identified as the problem areas with the greatest need for additional probrmas. Programs in most of these areas have since been made available. The library presently contains over sixty programs.

Role of the Programmable Calculator in Extension Programs

Extension staff members have found programmable calculators and programs useful for helping farmers solve management problems on an individual basis. Complicated budgeting procedures can be utilized to provide individualized answers quickly and accurately. Repeat users are encouraged to acquire and learn to use their own calculators.

Use of the programmable calculator can also speed up preparation time of educational materials for extension meetings, particularly when a series of budgeting examples is to be used.

It is even possible to work examples during a meeting by utilizing the prewritten programs. Key variables can be changed according to data solicited from the audience, and the effects quickly shown. In addition, audience interest is stimulated by the use of a new "gadget," and the image of the educator is enhanced by the use of an innovative tool. When using the programmable calculator in a meeting format, it is desirable to have a work sheet on an overhead transparency or large chart so that the audience can see exactly what values are being inputted and outputted.

Summary and Conclusions

Recent experience with the programmable calculator in a program developed through the Cooperative Extension Service in Iowa would indicate that it has useful application in areas of agricultural management decisions. It is an intermediate tool of analysis, with capacity for data storage and program execution, and should be viewed as a complement to the large capacity of the centralized computer. The calculator's low cost for both the hardware and software, ease of programming and sufficient capacity to handle many agricultural decisions makes it a valuable tool to Extension workers in meeting preparation and direct farmer assistance, and to farmers and agribusiness firms for day-to-day decision making.

A survey of the subscribers to the program library indicated there is a broad occupational group using the tool in agriculture, including many people engaged in service to farmers. Of the farmer respondents, most were cattle and hog producers. Respondents learned about the calculator mostly through Extension meetings and farm magazines. The most common problem in using library programs was in keying programs into the calculator and recording them onto magnetic cards. Having a printer or possessing some programming skills significantly reduced this difficulty. Respondents indicated that if programs were sorted in an internal module this would eliminate most of their problems in using the library. Further developments in this area should significantly contribute to wider use of the programmable calculator in agricultural education and management, and faster, more complete analysis of many agricultural management decisions.

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