A CASE STUDY

A Computerized Simulation Model For Teaching Dairy Herd Management

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Introduction

Management of livestock operations involves strategic and tactical decisions. Tactical decisions are the "day to day" decisions on individual animals and responses to situations in order to meet the desired goals of the operation. Strategic decisions are also made to meet the desired goals but are longer term and made infrequently. Examples of the latter in a dairy herd are: Should I expand the herd? Should I milk three times a day? A course in herd management should give students experience with both types of decision making and allow the students to see the consequences of their decisions.

In order to give students experience with consequences of decision making, two computer programs were developed on a SuperCalc[3] (SuperCalc[3], Sorcim/INS, Computer Associates International, San Jose, CA.) electronic spreadsheet. The outcome of each decision attempted to mimic the basic principles of dairy science, biological variation and economic uncertainties.

Whenever new content or a new method of instruction is introduced in a course, it is necessary that a determination be made as to whether the intended objectives are being achieved. This evaluation is an essential task of every teacher. One of the first steps in evaluation of instruction is the specification of outcomes to be measured. For this simulation model, the outcomes of interest were student perceptions of the overall simulation model, the content of the material used within the model and the characteristics of the computer program itself. The overall simulation model was designed to assist students in (1) applying previously gained knowledge in a realistic decision-making scheme, (2) obtaining a better understanding of management decisions, and (3) increasing interest in dairy herd management.

The Computerized Simulation Model

The two programs in the model are described briefly so that others can use the ideas for developing management models for other animal and crop enterprises. In the dairy herd program, students made breeding, culling and herd replacement decisions on 20 cows. The starting herd was 40 cows; therefore, the consequences of each decision were doubled. If the herd was expanded to 60 or 80 cows, the consequences of each decision were tripled or quadrupled. The production of a cow was determined by her age, her previous production or inherited potential for a first-lactation cow, and a computer-generated random factor between 0.8 and 1.2. Likewise, the sex of the calf, death of a calf, services per conception, and whether a cow was involuntarily culled were determined by computer-generated random numbers.

Replacement animals could come from heifers raised in the herd or from a list supplied to the student containing production potential data, purebred or grade of each animal, classification score of purebred animals, and price. Semen with varying prices from 10 bulls with varying milk and type transmitting abilities were available each year. Any cow or calf could be sold but the herd size had to remain constant except for herd expansion. A male calf had a sale value of $50 unless his dam was purebred, had a type classification score of at least 85, and outproduced her herdmates by 4000 pounds of milk, at which time the calf was worth $3000. After all the decisions had been made on individual cows, new random numbers were generated and the spreadsheet then produced the following data: average production per cow, cows involuntarily culled, sex and production potential of calves, value of cows and bull calves, services per conception, and semen costs.

The data from the dairy herd spreadsheet were manually transferred to the second program, which was a spreadsheet containing the economic analysis. Other economic data were given to students on a weekly basis and included price per hundred-weight milk sold, value of cull cows, feed prices, health costs, testing and registration fees, utilities costs, bedding costs, marketing costs, hired labor costs, and miscellaneous supplies costs. It was assumed that 3000 hours of family and operator labor were available each year. Labor requirements above this amount were charged to hired labor. Feed requirements were determined by the spreadsheet using data on body weight, milk production, milk fat test, and pregnancy requirements from the National Research Council requirements. All feeds were assumed to be purchased.

Fixed costs of depreciation, taxes, insurance, repairs and interest payments were given to the students weekly. The dairy operation consisted of the dairy herd, buildings, equipment, and young stock.

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The initial value of the operation was $133,000 with an outstanding mortgage of $20,000. The spreadsheet calculated the income over variable, feed, as well as fixed costs and payment on principal. From remaining income, 25% was subtracted for income taxes and social security payments and $20,000 was subtracted for family living expenses. The money left over was considered gain, which earned interest or could be used to pay for future expansion.

The program was designed to determine the cumulative benefits of decision making. Each week of the term coincided with one year of operation. Emphasis was placed on making and implementing strategic decisions and on net worth. Strategic decisions made by the students included: purebred -vs- grade herd; emphasis on production -vs- type on the breeding, culling and herd replacement program; amount of voluntary culling of cows beyond a 20% involuntary culling rate; buying -vs- raising replacements; three feeding program choices; milking 2 or 3 times per day; and expansion of the herd.

Two opportunities were available for herd expansion — during the fourth and seventh years. Expansion had to be in multiples of 20. It was assumed that the 40 cow herd was milked in a stanchion barn and expansion beyond this number required a milking parlor and a free stall barn. Cost of the expansion reflected these changes. Students were required to calculate the cost of expansion from data supplied and included buildings, equipment, cows and replacement animals. Money for the buildings, equipment, and cows was borrowed for 10, 7 and 5 years respectively. A 20-line program written in BASIC was used to calculate the yearly mortgage and interest payments.

Evaluation

Reaction of the students to a new instructional technique provides important information to the instructor. The information can be used in a formative way to revise and improve the procedures so that the simulation model will be more effective in the future. It can also be used in a summative way to make decisions about whether this approach to instruction merits further utilization. Professors who are concerned about the quality of their instruction will be interested in the perceptions of their students about the appropriateness of instructional methods and content.

Student reports and grading

At 3-week intervals, students were required to hand in their results, which included an outline of their strategic decisions and a brief evaluation of the impact of their decisions on milk production per cow and net worth. Results were discussed in class. Students developed a strong interest in the program and competition among students soon developed.

The milk production per cow started at 16,037 pounds for all students and at the end of the quarter ranged from 18,460 to 23,825 pounds among students. The net worth values among students at the end of the quarter varied from $258,000 to $695,000. At the end of the term, the reports were graded on the basis of the development and implementation of the strategic and tactical decisions.

Student perceptions

Four global items were developed to measure student perceptions of the overall simulation model, 15 specific content items were developed to measure student perceptions of the subject matter used within the model and 16 program characteristics items were developed to measure student perceptions of the utility of the computer program. An evaluation form was given to each of the nineteen students who were asked to indicate their extent of agreement with each of the 35 statements on the scale of strongly agree, agree, disagree or strongly disagree. All forms were returned. The four global statements are listed in Table 1. The overall mean of the 4 global statements was 3.32 (on a 4-point scale) with a standard deviation of .48.

Subject matter perception was related to improved knowledge and understanding of the instructional content with questions listed in Table 1. The mean score for all 15 questions was 3.19 with a standard deviation of .37. All but two of the questions had a mean score of 3.0 or above. Those below 3.0 were, "the program gave me a better understanding of the relative importance of the sire and dam in inheritance of milk production and type" and "the program caused me to question the economic consequences before considering a change to 3X a day milking." Means were 2.83 and 2.79. The question receiving the highest mean score of 3.47 was "the program caused me to question the economic consequences of a decision before it was made."

The utility of the program was evaluated with questions which were worded negatively. Therefore, the disagree and strongly disagree responses were most prevalent. Questions are listed in Table 1. Responses were also coded so agreement with the negatively-worded statement received a low score and disagreement a high score. Scores on this section could therefore be compared directly with the previous two sections. The overall mean of the 16 questions was 2.84 with a standard deviation of .24. The only question with a mean score below 2.4 was, "inputs could be manipulated to produce the desired outcome." It had a mean value of 2.0, indicating agreement that inputs could be manipulated. Part of this response was due to one "bug" in the program at which high random numbers kept appearing in 3 columns and students could move cows into these columns if they wanted them culled or to produce a male calf. This "bug" has since been eliminated.

Reliability coefficients were calculated for each of the three variables. The alpha value for the four global questions was .70, that for the content questions was .87 and that for program characteristics was .64. These results indicate that the ratings for the items within each of the three scales had a satisfactory level of internal consistency.

Conclusion

Students were highly supportive of the overall goals of the course and its content. However, they were less supportive of some of the specific aspects of the computer program.

The use of this evaluation procedure enabled the course instructor to identify and correct problems in the computerized simulation model. Revisions will result in even more effective instruction in the future.

Table 1. Means, Standard Deviations, and Cronbach's Alpha Reliability of Student Ratings of a Computerized Simulation Model.

Item	Mean[1]	s.d.
Global Comments		
1. The program helped me to apply previously gained knowledge in a realistic decision-making scheme.	3.32	.58
3. The program increased my interest in dairy herd management.	3.21	.79
4. The program was an important part of the course and should be continued in future years.	3.42	.61
Mean and Standard Deviation for all Global Comments	3.32	.48
Cronbach's alpha for the global scale = .70		
Specific Content Questions		
1. The program gave me a better understanding of the importance of strategic decision making in dairy herd management.	3.37	.50
2. The program gave me a better appreciation of the biological variations that occur in a dairy herd.	3.05	.52
3. The program gave me a better understanding of the uncertainties involved in dairy herd management.	3.21	.53
4. The program gave me a better understanding of many factors of dairy herd management that are not under operator control.	3.37	.60
5. The program gave me a more realistic appreciation of the factors to consider in selecting bulls for use in the herd.	3.10	.66
6. The program increased my knowledge of the variable costs involved in dairy management.	3.16	.76
7. The program increased my knowledge of the financial factors and terms used in the economic evaluation of a dairy operation.	3.32	.58
8. The program gave me an appreciation of the costs and consequences of expanding the dairy herd.	3.37	.50
9. The program caused me to question the economic consequences of a decision before it was made.	3.47	.61
10. The program gave me a better understanding of cumulative effects of the strategic decisions that were made.	3.37	.50
11. The program increased my knowledge about economic consequences of raising instead of buying herd replacements.	3.16	.60
12. The program increased my knowledge and appreciation of involuntary culling and voluntary culling under operator control.	3.10	.66
13. The program gave me a better understanding of the relative importance of the sire and dam in inheritance of milk production and type.	2.83	.62
14. The program gave me a more realistic appreciation of the relative value of purebred and grade animals.	3.10	.81
15. The program caused me to question the economic consequences before considering a change to 3X a day milking.	2.79	.92
Mean and Standard Deviation for Specific Content Questions	3.19	.37
Cronbach's Alpha for the specific content scale = .87		
Program Characteristics		
1. The program required too much time in relationship to the learning benefit received.	3.00	.47
2. Written instructions were not sufficient for ease of computer operation.	2.68	.58
3. Errors during the program could not be corrected, so students had to start at the beginning.	2.42	.77
4. The program instead of the inputs could be manipulated to produce the desired outcome.	2.00	.82
5. The program was much too complicated and involved for a 300 level course.	3.32	.48
6. Too much emphasis was placed on the economic consequences of decisions.	3.05	.62
7. Some of the program calculations were not realistic.	2.56	.57
8. The program as a whole was not a realistic representation of a dairy herd.	3.11	.32
9. Not enough choices (i.e. bulls, replacement animals) were available.	2.90	.66
10. The costs of inputs were not realistic.	3.11	.46
11. The program seemed to be biased towards grade cows.	2.90	.31
12. The reasons for some of the biological and economic calculations were not clear.	2.58	.69
13. I had difficulty attaining access to the computer.	3.00	.74
14. Prices and inputs for 2-3 years should have been made at one time instead of on a weekly basis.	2.78	.88
15. The program required a lot of manipulation for which the reasons were not clear.	2.89	.47
16. More than 20 cows should be available on which individual decisions are made.	3.22	.55
Mean and Standard Deviation for all Program Characteristics	2.84	.24
Cronbach's Alpha for the Program Characteristics Scale = .64		

[1]Items were rated on the following scale: 4 = Strongly Agree, 3 = Agree, 2 = Disagree, 1 = Strongly Disagree. (Negative Statements were Reverse Coded)