A simulation exercise to teach principles of bovine reproductive management[1]

G. A. Perry[2] and M. F. Smith[3]

Department of Animal Science, University of Missouri, Columbia 65211

ABSTRACT: Students in Reproductive Management (a senior-level course with approximately 20 to 50 students per semester) at the University of Missouri–Columbia are required to participate in a simulation exercise that is designed to improve reproductive efficiency in a beef herd. During a simulated 5-yr period, students must 1) improve reproductive efficiency in a beef cowherd through implementation of reproductive management principles; 2) determine the economic impact of reproductive management decisions in a beef herd; and 3) evaluate the constraints of different geographical locations on approaches to reproductive management. Groups of three to four students are provided with the reproductive and economic records of a farm/ranch located in different parts of North America. Students create reproductive management plans consisting of 1) detailed discussion of farm/ranch environment (climate, terrain, forage and grain availability, and stocking rate; season for breeding and calving; and justification for choice of breed); 2) assessment of current level of reproductive performance; 3) identification and economic justification of specific (measurable) objectives; 4) discussion of alternatives for accomplishing specific objectives; 5) prediction of reproductive performance (pregnancy rate, quantity of calf weaned per cow exposed, and cost per quantity of calf weaned) in response to implementation of specific management practices; and 6) an annual and 5-yr reproductive and economic summary. Students obtain livestock marketing information for their assigned location via the Internet. Spreadsheets were developed to calculate the reproductive efficiency of postpartum cows and replacement heifers based on management decisions made by the groups and to calculate a yearly economic summary for each of the 5 yr. Management decisions are justified in a written report, and oral presentations are given to the class when the project is completed. Greater than 85% of students indicated that the exercise increased their understanding of how management decisions affect reproductive efficiency and profitability in a beef operation and also provided added confidence for students that applied for beef management positions.

Key Words: Beef Cattle, Curriculum, Reproduction, Simulation, Exercise, Teaching

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Introduction

Teaching students to critically analyze and integrate information is a common goal among educators (Kurfiss, 1988; Nelson, 1997). To accomplish this goal, students must develop the ability to understand, retain, and integrate the fundamental principles of the subject to be learned. More specifically, when teaching beef cattle reproductive management, it is necessary for students to integrate information from a variety of sources and to evaluate the effect of a single management decision on future reproductive performance and profitability in farm/ranch operations.

To facilitate learning, students must first possess the "need to know" (Newcomb et. al., 2003). Student motivation has been described as a determining factor regarding whether some students achieve more than other students with similar talents (Campbell, 1977). Therefore, developing instructional strategies that motivate students to learn is a primary concern of educators (Taylor and Kauffmann, 1983). To create the "need to know," students must do more than memorize facts; they must be active participants in the learning process (Kauffman et al., 1971). Active participation in the learning process enhanced the ability of students to think, use, and retain information (Ladd, 1987). Furthermore, experiential learning exercises have been

[1]The authors dedicate this manuscript to the memory of J. N. Wiltbank, who used a similar approach to teach beef producers, undergraduate students, and graduate students the effect of management decisions on subsequent reproductive performance of beef cattle.

[2]Present address: Dept. of Anim. and Range Sci., South Dakota State Univ., Brookings 57007.

[3]Correspondence: 160 Animal Science Research Center (phone: 573-882-8239; fax: 573-884-7827; e-mail: Smithmf@missouri.edu).

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found to increase cognitive learning among students (Bloom et al., 1964). The preceding mentioned exercises/projects allow students to develop critical thinking skills and to synthesize and integrate information from a variety of courses. Our objectives were to create a simulation exercise that accomplished the following specific aims: 1) to increase student knowledge and retention of reproductive management principles; 2) to promote critical thinking skills; 3) to promote the integration of information, from a variety of courses, in a production environment; and 4) to clearly illustrate the effects of specific management decisions on the production and economics of a beef operation.

Materials and Methods

Students (juniors or seniors) were divided into groups of three or four based on experience level: 1) no farm background only animal science classes; 2) some farm experience (summer job, internship); 3) raised on a farming/ranching operation. A student with moderate to extensive background in beef production was placed with each group and designated the group coordinator. By assigning students to groups based on experience, students were able to learn from each other and build on collective experiences. Each member of the group took responsibility for a specific section(s) of the final report and oral presentation and was responsible for making sure their section(s) was completed in a timely fashion.

Approximately 5 wk after the beginning of the semester, groups were assigned to a specific geographical location (each group was assigned a farm/ranch in a different area of the United States) and were required to secure information about this location. Each group was then provided with a set of production records for a fictitious farm/ranch, as well as general farm/ranch information. The production records for the farm/ranch included a current inventory of cattle, including 1) the number of replacement heifers (n = 50) separated into the 20-d calving groups into which they were born; 2) the number of pregnant cows (n = 305) separated by body condition score at calving (thin [n = 103] or moderate [n = 202] body condition) and into the 20-d calving groups into which they were expected to calve (140-d calving season); 3) the number of nonpregnant/nonlactating cows (n = 50); and 4) the number of bulls (n = 15). The herd records also included the number of calves born in each calving period during the previous year, as well as their ages and weaning weights. The general farm/ranch information included 1) herd size (n = 355 cows and 50 replacement heifers); 2) annual cow costs; 3) annual heifer costs; 4) annual bull costs; 5) cost of gain for replacement heifers and cows in different reproductive states; 6) average calf birth weights; and 7) ADG from birth to weaning for heifer and bull calves born to replacement heifers and cows. The objective for each group was to economically improve reproductive performance while maintaining a herd size of 300 to 325 breeding females (all information provided to each group is also available on the Internet: http://www.asrc.agri.missouri.edu/SmithMF/Repro~Management/planpageRM.htm).

The first assignment was for the group to investigate the environment (climate, terrain, primary forage, availability of grain, stocking rate, and amount of land needed to maintain an operation of this size) in which its farm/ranch was located. The first decisions made by the groups were to determine season of the year for calving and breeding and the choice of breed or breed cross. Each group had complete flexibility regarding the preceding decisions; however, they were required to justify their decisions based on the geographic location and the farm/ranch environment.

The groups were subsequently supplied with target weight and estrus synchronization information for replacement heifers, and postpartum interval and estrus synchronization information for cows. Groups assumed management responsibility of the farm/ranch on the day the first calf was born, and developed a plan for economically improving reproductive performance over the next 5 yr.

Each group was free to use any management practices it believed would increase reproductive performance and be economically justifiable (i.e., natural service or AI, one breeding season or multiple breeding seasons, development or purchase of replacement heifers, embryo transfer program, etc.). To aid the students in their decision-making, Microsoft Excel worksheets were developed by the authors to calculate the reproductive performance of heifers (Table 1) and postpartum cows (Table 2) following the implementation of specific management practices. In addition, yearly economic summaries were developed, based on production expenses and income, to determine the financial impact of the groups' management decisions (Excel worksheets and instructions are also available on the Internet: http://www.asrc.agri.missouri.edu/SmithMF/Repro~Management/Repro~Plan/Repro Plan.xls).

Groups were encouraged to explore different marketing options for their calf crop (market at weaning or retain ownership until the calves entered the feedlot or were harvested). The price of weaned calves was set by the price of the local sale barn at each location on a specific day (sale barn information is available on the Internet: http://www.ams.usda.gov/lsg/mncs/ls_main.htm).

Each group had to summarize the reproductive performance and expenses/income for each of the 5 yr; therefore, showing how decisions made in one year affected performance in future years.

The final written report included 1) calculations (pregnancy rate, percentage of calf crop weaned, breakeven price, etc.) of the current level of reproductive performance in the herd and a discussion of the reasons for the current low level of performance; 2) a list of specific goals to be accomplished and an economic justification for each goal; 3) a discussion of different alter-

Table 1. Example of spreadsheet developed to calculate reproductive efficiency in developed heifers[a]

Breeding period	Calving group born in	Age, mo	Weight	Breeding date	No. of head	Cycling, %	Total estrus response	Previously pregnant	No. in estrus this period	Conception rate, %	No. pregnant
1(A)	1(B)	C	D	E	F	G	H = F × G	I	J = (F × G) − I	K	L = J × K
1	2										
2	1							= L			
2	2										
3	1										
3	2										
Group	Average conception date	Expected calving date	Weaning date	Age	Birth wt.	Daily gain	AI	Weaning weight	No. of calves	Quantity weaned	
1	M = E	N = M + 285	O	P = O − N	Q	R	S	T = (P × R) + Q + S	U = L	V = L × T	
2	= E + 20										
3	= E + 40										

[a]A = each 20-d period of the breeding season; B = each 20-d period of the calving season during which the heifers were born; C = age in months heifers are at start of breeding period; D = weight in pounds heifers are at start of breeding period; E = beginning date of each breeding period; F = number of heifers in each calving group; G = percentage of heifers cycling based on age and weight at the start of the breeding period; H = F × G; I = the number of heifers that became pregnant during the previous breeding periods; J = (F × G) − H; K = the percentage of heifers expected to conceive during that breeding period; L = J × K; M = E (beginning date of each breeding period + 10 d); N = M + 285 (average gestation length); O = date calves are going to be weaned; P = O − P; Q = average weight of calves at birth.; R = ADG by calves; S = genetic benefit gained from using AI sires in the form of weight (or mass) weaned; T = (P × R) + Q + S; U = L; V = L × T.

natives for attaining each goal; 4) an annual timeline of specific production practices (calving season, breeding season, weaning date), specific procedures, predicted reproductive performance (pregnancy rate and quantity of calf weaned), and an economic summary for each year; and 5) a final 5-yr summary that included reproductive performance and net profit or loss for each of the 5 yr. Finally, each group presented and defended their plan to the class.

Results and Discussion

Teaching students to synthesize and evaluate information for the purpose of solving a problem is a critical component of agriculture education. Farmer (1988) proposed that "Education in most colleges and universities is fragmented. Students experience the curriculum as a collection of courses rather than as an integrated plan of learning." Neill et al. (1996) suggested that "Collegiate curricula in agriculture are overburdened, with too many courses that have too much complexity, too much technical content (facts and figures), and too much redundancy—but not enough connectedness to one another and not enough apparent relevance to the real world." A primary objective of the reproductive management plan described here was to provide a learning environment that required students to make connections among concepts presented in lecture/laboratory sessions and a production livestock enterprise (i.e., cow calf operation). The reproductive management plan provided a context in which students could analyze a problem (i.e., poor reproductive performance in a beef herd), identify specific and achievable objectives, apply management strategies for accomplishing each objective, predict the reproductive performance and economic impact of specific management strategies, and summarize the results after five years of management.

At the end of the project, students were asked to write a confidential evaluation that would specify strengths, weaknesses, and their opinion on if the project effectively incorporated the information provided in class to an applicable situation. Specific strengths of this teaching approach, which were frequently mentioned by students in the confidential evaluation, included the following: 1) the plan provided an effective method of learning basic concepts of reproductive management; 2) the plan increased student understanding of geographical/environmental constraints on reproductive management; and 3) the plan clearly illustrated the effect of specific management decisions on animal productivity and profitability (Table 3). The primary criticisms, from the student viewpoint, included the following: 1) the plan involved a lot of work and was time consuming, and 2) the plan was focused entirely on reproductive management and did not include other variables that affect beef production (i.e., forage program, herd health, genetic selection, etc.). With regard to the first criticism, the estimated time to complete the project was approximately 30 to 40 h over a 10-

Table 2. Example of spreadsheet developed to calculate reproductive efficiency in cows[a]

Breeding period	Previous calving group	No. of cows	Previously pregnant	Previous calving date	End of breeding period	Days postpartum	% Cycling	No. in estrus	No. anestrus	% Anestrous response	No. anestrus in estrus	Total estrus response	Conception rate	No. pregnant
1(A)	1(B)	C	D	E	F	G	H	I = C × H	J = C − I	K	L = J × K = L	M = (I + L) − D	N	O = M × N
1	2													
2	1		= O											
2	2													
3	1													
3	2													

Group	Average conception date	Expected calving date	Weaning date	Age	Birth wt.	Daily gain	AI	Weaning wt.	No. of calves	Quantity weaned
1	P = F − 10	Q = P + 285	R	S = R − Q	T	U	V	W = (S × U) + T + V	X = O	Y = W × X
2	= E + 20									
3	= E + 40									

[a]A = each 20-d period of the breeding season; B = each 20-d period of the previous calving; C = number of Cows that calved during that previous calving season; D = the number of cows that became pregnant during the previous breeding periods; E = the average calving date from the previous calving season for that calving period; F = the last day of that breeding period; G = the average number of days since calving for that calving group; H = the percentage of animals expected to be cycling during that breeding period; I = C × H; J = C − I; K = the percentage of anestrous cows that would respond to the estrous synchronization protocol if one is used; L = J × K; M = I + L; N = the percentage of cow expected to conceive during that breeding period; O = M × N; P = E (ending date of each breeding period minus 10 d); Q = P + 285 (average gestation length); R = date calves are going to be weaned; S = R − Q; T = average weight of calves at birth; U = average daily gain by calves; V = genetic benefit gained from using AI sires in the form of weight (or mass) weaned; W = (S × U) + T + V; X = O; Y = W × X.

Table 3. Distribution of student experience and advantages/disadvantages of the reproductive management project as listed in confidential student evaluations (n = 140) over 4 yr (1999 to 2002)

Distribution of students' previous experience with beef cattle		
Experienced[a] 26%	Some experience[b] 16%	No experience[c] 58%
Advantages of the reproductive management plan		
Very effective at reinforcing concepts and techniques presented in class.		
Allowed students to understand the effect of management decisions on productivity and profitability.		
Enabled students to understand why different management decisions are made in various parts of country.		
Allowed students to learn from other group members.		
Allowed students to learn where to find information.		
Allowed students to develop critical thinking skills.		
Increased student enthusiasm through competition among groups.		
Increased student understanding of the economic impact of specific management decisions.		
Allowed students to see how decisions affect profitability.		
Gave students a "hands-on" perspective of cow-calf management.		
Allowed students to develop a big picture of the beef industry.		
Disadvantages of the reproductive management plan		
Project was very time consuming.		
Project involved a lot of work.		
Project focused on reproduction and did not include all variables that affect beef production.		

[a]Students that were raised on cattle operations and began the class with a personal knowledge of beef cattle production.
[b]Students that were not raised on cattle operations but began the class having worked with cattle in a production situation (i.e., summer internship program or summer job).
[c]Students whose only previous experience with beef cattle was from their animal science courses.

wk period, and the workload could be shared by the members of the group (three to four students; 10 to 15 h per student). McKeachie (2002) reported that an acceptable expectation is for undergraduates to spend 1 to 2 h outside of class for every hour in class. With respect to the second criticism, the simulation exercise could be easily expanded to encompass additional variables that impact a cow-calf operation.

Over a 4-yr period (1999 to 2002), 140 students have enrolled in the course and their experience level with beef cattle production was categorized as follows: experienced (26%), some experience (16%), or no experience (58%; Table 3). A common challenge in an animal science curriculum is to effectively teach animal production oriented courses to students with widely varying experience levels. One strength of the reproductive management plan described herein is that the plan created a learning environment, which allowed less experienced students to learn from the more experienced students. Furthermore, the less experienced students were often able to offer new approaches or to challenge the traditional management strategies proposed by the more experienced students. When asked to evaluate the project, 93% of the students indicated that the project enhanced their understanding of how to improve reproductive performance in a beef herd (Figure 1). In addition, 85% of the students said that the project enhanced their understanding of how management decisions affect the economics of a cow-calf operation (Figure 2), and 67% of the students indicated that the plan increased their understanding of the overall beef industry (Figure 3).

The use of special projects allows students to be more creative and gives them more control over their learning (Schaefer and Kauffman, 1975). With the reproductive management plan, students quickly learned that the

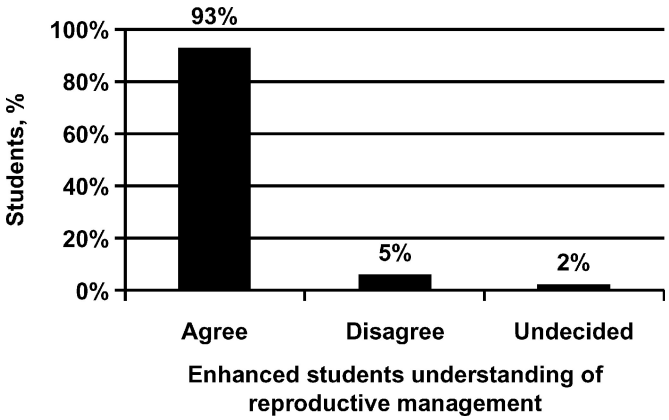

Figure 1. During a 4-yr period (1999 to 2002; n = 140 students) undergraduate students (seniors majoring in Animal Science) were asked, in a confidential evaluation form, whether the reproductive management project enhanced their understanding of how to improve reproductive performance in a beef herd. The percentage of students that agreed, disagreed, or were undecided is presented in the figure.

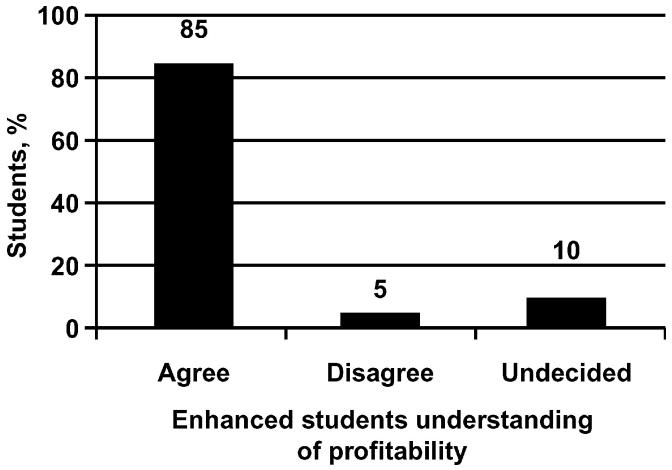

Figure 2. During a 4-yr period (1999 to 2002; n = 140 students) undergraduate students (seniors majoring in Animal Science) were asked, in a confidential evaluation form, whether the reproductive management project enhanced their understanding of how management decisions affect the economics of a cow-calf operation. The percentage of students that agreed, disagreed, or were undecided is presented in the figure.

development of an effective and profitable plan depended on their understanding of the basic concepts presented in lecture. Based on observations of the authors, students also quickly realized the importance of sharing ideas, strategies, and prior experiences in the development of their management plan. This created a learning community among the students in which to learn and fully understand the information that was being taught. This is consistent with other simulation experiences, which can lead to a deeper and more enduring understanding of accumulated discipline knowledge; these experiments not only generate a high level of enthusiasm and involvement, but the assignments and discussions with students appear to enhance learning (Koontz et al., 1995).

Some students even sought out additional information about beef cattle management decisions (i.e., the use of stocker cattle and retained ownership) to possibly increase the profitability of their farm/ranch. Therefore, use of special projects can promote an increased desire to gain a deeper understanding of the subject area and inductive learning, which involves the synthesis of the big picture from various disparate pieces. The benefits gained from the use of special projects and hands on teaching techniques have caused an increase in their use throughout the country (Vogelsang et al., 1989; Allee and Kerley, 1995; Koontz et al., 1995).

With the present project, students with varying backgrounds clearly recognized the benefits from participating in the simulation exercise, and after completion of the project, students demonstrated an increased understanding of how to make decisions and evaluate alternative methods to achieve their management goals. The overall goal of the simulation exercise was to create a learning experience that allowed students to increase their knowledge and retention of reproductive management principles, promoted critical thinking skills, promoted the integration of information in a production environment, and illustrated the effect that management decisions have on the productivity and economics of a beef operation. As indicated by the student evaluations, this project did increase students' understanding of reproductive management practices, profitability, and the beef industry. Furthermore, students indicated that this project allowed them to apply lecture material from class to a more real world situation and to evaluate how decisions that were made influenced productivity and economics.

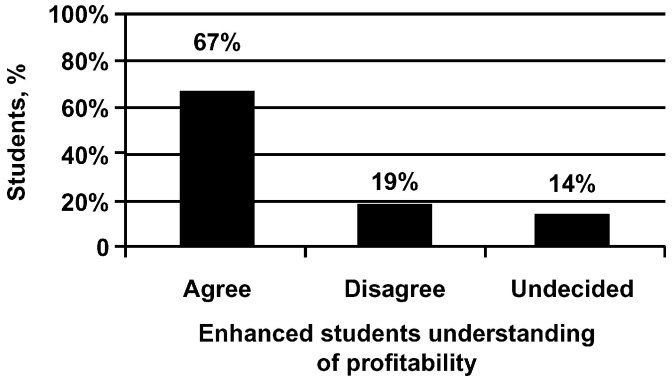

Figure 3. During a 4-yr period (1999 to 2002; n = 140 students) undergraduate students (seniors majoring in Animal Science) were asked, in a confidential evaluation form, whether the reproductive management project enhanced their understanding of the overall beef industry. The percentage of students that agreed, disagreed, or were undecided is presented in the figure.

Implications

Motivating students to learn is a primary concern of educators and depends on creating the "need to know." The development of a simulation exercise focused on economically maximizing beef cattle reproductive performance created a competitive atmosphere in which the students expressed a desire to learn, developed problem-solving skills, and were required to integrate concepts from several courses. The use of role-playing and hands-on experiences to increase the understanding of a subject area can be used regardless of discipline to create a desire to learn among students.

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