Development and Implementation of a National Center of Excellence in Dairy Production Medicine Education for Veterinary Students: Description of the Effort and Lessons Learned

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ABSTRACT

The need for consortial programs to provide advanced education in food animal veterinary production medicine has been recognized and lauded for nearly three decades. This article describes one effort to create a dairy production medicine curriculum funded by a United States Department of Agriculture (USDA) Higher Education Challenge Grant. This National Center of Excellence in Dairy Production Medicine Education for Veterinarians is housed at the Dairy Education Center of the University of Minnesota and the project was a collaboration of the University of Minnesota, the University of Illinois, the University of Georgia, and Kansas State University. The article reviews the need for innovative ways to educate students who will optimally serve the dairy industry, provides a broad overview of the process of developing and delivering the eight-week dairy production medicine curriculum, and describes the challenges faced and lessons learned as a result of offering such a program.

Key words: dairy veterinary education, dairy production medicine, centers of excellence, food animal veterinary education, veterinary manpower, curriculum, design, delivery, assessment, observations, consortia

OVERVIEW

For some time now, food systems in the United States (US) have been undergoing rapid and fundamental change. Production efficiency, animal welfare, prudent drug use, environmental impact of farms, security of the food supply, and food exports play increasingly crucial roles in serving the quality of life for the nation. Veterinary professionals play key roles in animal production and the subsequent food chain, protecting animal health, welfare, productivity, food safety and public health. Despite continuing demand for qualified veterinary professionals, the number of veterinarians serving food production systems is declining.

Veterinarians who serve the dairy industry must be equipped to address management, disease prevention, and food safety and security issues, help producers maintain profitable operations, and understand the complexity of the dairy food system. Students who graduate from veterinary school without such "dairy production medicine" skills will be at a distinct disadvantage in practice and may find it difficult to find a sustainable role in the dairy industry. Attrition of food animal-oriented faculty and contraction of teaching resources have resulted in most veterinary colleges lacking sufficient resources to deliver the necessary training to achieve competence in entry level practitioners in these areas of emphasis. In order to serve and protect the nation's food systems, new collaborative approaches to veterinary manpower development are urgently needed.

This article describes one such approach to preparing veterinary students to serve the dairy industry. As background, we will first review the current status of the US dairy industry, the need for and supply of dairy veterinarians, and previous attempts to provide the necessary training. We will then describe the National Center of Excellence in Dairy Production Medicine Education for Veterinarians (Dairy Center of Excellence [DCE]), with emphasis on the Center's development and curriculum. Companion articles will focus on the evaluation of student performance and outcomes in the first cohorts of students who participated in this effort.

BACKGROUND

The Status of the US Dairy Industry and Need for Dairy Veterinarians

Dairy products provide about 20% of the protein in the American diet and are crucial sources of calcium and vitamins.[1] Milk is particularly important for growing children and young women, who benefit from the readily-available protein and calcium. In 2015, the nation's 9.3 million dairy cows produced more than 200 billion pounds of milk[2] worth $36 billion of farm gate receipts.[2,3] The dairy industry's impact on the wider rural community is much larger than just farm gate milk receipts.[4]

Of the roughly 40,000 dairy farms in the United States, nearly all are family owned and operated.[5] While herd sizes vary widely, the average US dairy herd has about 200 cows.[5] Dairy farms are complex, multifaceted enterprises, generally including at least a milking herd operation, a youngstock rearing operation, crop and forage production, environmental management, employee management, and financial management. The wide span of enterprises and the sophisticated technology in use on dairies mean dairy producers must turn to highly trained specialists for information and guidance in managing their farms and to ensure safe products. Without adequate veterinary manpower in rural America, the sustainability of a key sector of the rural economy, its resiliency to external pressures, and the continuity of local business activity may suffer.

The dairy industry continues to consolidate into larger farms and to face challenges that were never faced by earlier generations. The dairy industry must now deal with demands for accountability for animal welfare and product safety, as well as for product quantity and wholesomeness, and to attend to a broad array of environmental challenges and social expectations. Milk processors, importing countries, and consumers are all making demands regarding production techniques, certification, process transparency, and trace back of product. On larger dairies, most day-to-day work is done by employees, not the owner. This means that the need for specialized training, supervision, and standardized system development becomes paramount.

As the dairy industry has evolved, so too have the demands made of veterinarians. Because the individual cow is sufficiently valuable to warrant medical and surgical care, today's dairy veterinarian must still possess those traditional skills. In addition, dairy veterinarians are called upon to use sophisticated information systems to monitor herd performance and disease trends, evaluate milking systems, develop treatment protocols, monitor drug use, design or oversee programs related to nutrition, disease control, reproduction, biosecurity, and youngstock management, promote animal welfare, and consider the economics associated with all recommendations and actions. Veterinarians play sophisticated roles as production system managers, consultants, and technical service personnel, and are essential to our food protection and defense systems. They provide expertise beyond the farm gate as dairy products are processed and distributed. There is an urgent need for veterinarians who understand the entire dairy food chain and who can operate within the large-scale, complex, and technologically sophisticated systems that bring food to the American and world's table.

Supply of Dairy Veterinarians

While the need for veterinarians in the dairy industry is critical and the range and sophistication of necessary skills are expanding, the supply of properly trained dairy and food system veterinarians is shrinking. As of 2015, there were 8,781 veterinarians serving in large animal (food animal exclusive or predominant) or mixed animal practice in the United States; another 2,862 veterinarians worked in state and federal governments.[6] In a 2013 survey by the American Veterinary Medical Association with 96% of all graduates responding, only 4.2% of graduates entered food animal exclusive or food animal predominant practice.[7] Only a subset of those graduates would have entered dairy practice. Just 0.1% entered state or federal veterinary service. These data serve to illustrate the challenges for recruitment of veterinary students into large animal practice despite better starting salaries as compared to some small animals and equine jobs. The number of students entering large animal practice immediately after graduation from veterinary school is poorly matched to replace retiring and exiting practitioners and does little to promote expansion of the workforce, if such is needed. One of the corollary issues facing dairy veterinary medicine is the question of whether those new graduates who do enter dairy practice are sufficiently prepared to succeed in serving a consolidating and increasingly sophisticated dairy industry. This latter issue is the motivating driver for the project described in this article.

Veterinary Academia's Responsibility and Response

Much of the discussion around shortages of food animal veterinarians focuses on recruitment and admissions. There are currently fewer discussions about what it takes to make the recruited students successful once they enter the dairy veterinary profession. There have been calls for significant changes in food animal veterinary education for at least the past three decades.[8–17] In 2006, an entire edition of the *Journal of Veterinary Medical Education* was committed to issues relating to Veterinary Medical Education for Modern Food Systems.[18] In far more detail than can be presented here, the many contributing authors laid out the need for significant changes in the way colleges of veterinary medicine educate veterinarians who will serve our nation's food systems. In their report on the roles and responsibilities of academic veterinary medicine, the summary reads in part: "Schools and colleges of veterinary medicine are responsible to prepare their graduates to meet the needs of modern food supply veterinary medicine. To fulfill that responsibility, academic veterinary medicine must work closely with modern food systems to broaden the roles and impact of veterinary medicine and to educate graduates who can effectively fill new and expanded roles. Students must have opportunities to understand the full breadth and dimensions of modern food supply careers and they must be taken beyond the traditional view of

the food animal veterinarian to an understanding of the veterinary roles in consolidated, vertically integrated food systems, including the demand of food safety and food system protection. However, the roles, specific knowledge needs and the skills of veterinarians in the food systems of the future are so broad and unique that all the requisite knowledge cannot be included within a general veterinary medical education."[17]

The federal government/USDA recognized the need to at least partially re-shape food animal veterinary medical education by authorizing the creation of "Centers of Excellence" in food animal veterinary medicine in the Farm Bill of 2008. The bill states: "The Secretary shall prioritize regional centers of excellence including land grant institutions or schools of veterinary medicine to ensure coordination and cost-effectiveness by reducing unnecessarily duplicative efforts regarding teaching, using public/private partnerships among agricultural industry groups, institutions of higher education, and the federal government to implement teaching initiatives to improve teaching capacity and infrastructure at colleges and universities including schools of veterinary medicine." Unfortunately, no funding was then allocated for the centers of excellence concept.

No individual US veterinary college has all of the faculty expertise needed to produce well-equipped production medicine veterinarians in all food animal sectors. Most colleges lack sufficient clinical material and the necessary production system environments needed for specialized training. Many are located in states that lack a significant food animal industry in one or more sectors. For example, only eight colleges of veterinary medicine are located in a major dairy state (California, Wisconsin, New York, Pennsylvania, Minnesota, Texas, Michigan; states with both a veterinary school and at least 4% of the nation's dairy cows). Many colleges do not have strong public health or integrated programs that tie into food processing and biosecurity. Finally, there are not enough interested students at most veterinary colleges to justify investment in the expensive infrastructure it takes to provide specialized educational offerings. For example, each college typically only graduates a few students each year who are intent on a career serving the dairy industry. Using American Association of Bovine Practitioner (AABP) data, if 28 colleges of veterinary medicine graduated only 227 American students who were AABP members at their graduation in 2015 (201 in 2016), then the average veterinary school graduating class had only 8 future bovine practitioners (both dairy and beef).[7] The actual number in many veterinary colleges may be fewer than 8, and for dairy specifically may be fewer than 5. This dearth of large animal focused students poses a serious challenge for sustainability of large animal programs. Deans are unlikely to allocate the resources required to provide a dairy production medicine curriculum for these few students. Although the recent addition of new, purported food animal focused veterinary colleges may add a small number to the supply of dairy veterinarians, economic pressures may dictate that these schools will not achieve an outcome different from existing schools that were once prominently food animal based. Thus, national centers of excellence are needed to assure education programs to supply knowledgeable and competent entry level practitioners.

The need for food supply veterinarians is national in scope and the pool of potential students is spread thinly across the entire nation. There is little incentive for state legislatures that only partially fund veterinary colleges to then commit to new funding for infrastructure and programs to educate students from other states. The food animal veterinary human resources and training needs are a national problem, so the operating funds to address them will likely have to come from the national level as well.[19] Alternatively, consortia of veterinary schools would have to pool funds into one program. This is inhibited by the differing funding models for tuition and the need to maintain economic viability by the candidate schools

The American Veterinary Medical Association and various national task forces studying the education of food supply veterinarians have recognized the need to adopt consortial, cooperative approaches.[20–23] Again quoting from the executive summary from the *Journal of Veterinary Medical Education*: "The increasing sophistication and changing needs of modern food systems, combined with the growing resource limitations of academic veterinary medicine, make it impossible for each school and college of veterinary medicine to sustain high quality programs in all areas of animal health and food production. Consequently, discrete Centers of Excellence within individual schools and colleges, complemented by consortia and collaboration across institutions, must develop as a more efficient way to provide quality training, service, and research opportunities. In this model, students might be expected to obtain pre- and para-clinical education from their respective institutions; however, their clinical training might be programmed so they would spend most of their time at a center of excellence at another institution, gaining experience and expertise in the entire food system."[17]

Although consortia have been promoted and attempted for years, most US veterinary colleges still try to address food animal veterinary training in their own way as required by the American Veterinary Medical Association (AVMA) Council On Education.[24] Regarding dairy production medicine education, a few veterinary colleges in the position to do so have undertaken to provide the necessary depth and breadth for their own students (e.g., the University of Wisconsin[25]). Others have focused their efforts on recent graduates. A notable example is the Cornell Summer Dairy Institute; this program at Cornell University deserves commendation for its successful model that works to educate graduate veterinarians for roles in dairy production medicine.[26] The Summer Dairy Institute is now in its sixteenth year. Finally, over the past two decades there have been several outstanding multi-module continuing education certificate courses aimed at providing training to seasoned veterinary practitioners (e.g., at the University of Guelph, Pennsylvania State University and the University of Pennsylvania, the University of Wisconsin, and the Ohio State University). Unfortunately, some of these programs are no longer in operation.

THE USDA NATIONAL CENTER OF EXCELLENCE IN DAIRY PRODUCTION MEDICINE EDUCATION FOR VETERINARY STUDENTS

In 2011, the United States Department of Agriculture's (USDA) National Institute of Food and Agriculture (NIFA) Higher Education Challenge Grant program awarded a grant to a consortium of four veterinary colleges: University of Minnesota, University of Illinois, University of Georgia, and Kansas State University. The objectives of the grant were to create a center of excellence for dairy production medicine education and to design and implement a comprehensive production medicine course for senior veterinary students who were committed to a career serving the dairy industry. The first year of the 2-year grant was devoted to designing the curriculum. In the second year, the course was delivered to two cohorts of senior veterinary students in the Class of 2013. The course has since been offered to students in the Classes of 2014–2018 and the goal is to sustain it into the foreseeable future. The senior veterinary students who first participated in the course came principally from the four consortium colleges. Since then openings are made available to students from other veterinary colleges and some of the original collaborating colleges no longer send any students to the program. The course is delivered in two 4-week blocks of time during which the students live at the University of Minnesota's Dairy Education Center. The Dairy Education Center is the product of a 2009 public/private partnership between the University of Minnesota's College of Veterinary Medicine and a large commercial dairy farm in south central Minnesota. It was constructed, in part, to create a workable venue to implement the concept of a center of excellence for dairy veterinary education.

The Dairy Education Center is a 15,000 square foot, two story building constructed centrally on a large commercial dairy. The Center is under the same roof as the principal dairy building with classrooms that overlook a 72-cow rotary milking parlor on one side and a maternity unit with 10 large calving pens on the other. The dairy milks 3,000 Jersey/Jersey-cross cows three times a day in the rotary parlor. It also serves as the dry cow and calving facility for its own animals and for two nearby sister dairies of 3,000 milking cows each. When the first cohort of veterinary students participated in the DCE course, there were 8,000 calvings per year at the facility. Today there is a total herd of 10,000 cows and more than 10,000 calvings occur each year. The dairy ships its milk to a commercial cheese producer whose manufacturing plant 10 miles away processes over 2 million pounds of milk daily from local dairy farms. Thus, the educational opportunities within the system can span production, diseases, management, manufacturing, wholesale distribution, and aspects of food safety and food system security.

The Dairy Education Center has three classrooms, the largest of which can seat 60 students at tables with power outlets for computers. There are dormitory facilities for up to 24 students and two visiting instructors. The entire building is configured for wireless internet access. There is a wet lab area for demonstrations and hands-on activities, and a multi-chute area for surgery and other animal procedures. A research lab is equipped for routine diagnostic procedures such as clinical chemistry, microbiology, and hematology. There is a student locker room, kitchen, laundry room, academic office space, and all necessary building infrastructure. The Center is 15 minutes from Gustavus Adolphus College, a small liberal arts college in St. Peter, Minnesota. The students in the DCE course have access to the array of offerings at the Gustavus student cafeteria for evening meals. This provides a useful break in the evenings and is well received by the students.

CURRICULUM DESIGN

The DCE curriculum was designed and presented by faculty from the four collaborating colleges, with input and teaching participation from dairy production medicine experts at other colleges and outside of academia as well. An evaluation team, comprised of an education specialist and two academic affairs deans, was established early on to assist with curriculum design and outcomes assessment. Curriculum design was an iterative process, starting with a rough schedule of topics and some general concepts about delivery methods. The principal designing faculty and invited guests met at the Dairy Education Center for 3 days in January 2012 to begin to define goals, outline module content, discuss potential delivery methods, learning activities, and assessment strategies, identify module coordinators and presenters, and establish timelines and deliverables. The evaluation team gave a presentation that highlighted the need to identify desired outcomes up front, then design the curriculum to address the outcomes and incorporate assessments that evaluate them. The team emphasized the importance of using diverse learning strategies, giving formative as well as summative feedback, and using rubrics to convey expectations and standardize grading. Other participants gave presentations pertaining to the use of web and library resources, narrated PowerPoint presentations, and the Moodle[a] online learning software platform to promote and evaluate learning.

A substantial portion of the initial planning meeting was structured as breakout sessions, in which faculty and evaluation team members discussed plans for course modules. The breakout groups used a template to focus discussion and to promote alignment of module components. The template required faculty to propose desired competencies, goals (general outcomes), objectives (specific outcomes), teaching strategies, and assessment methods. Because there were no generally accepted compilations for key competencies for dairy production medicine, the participating experts from academia, industry, and dairy practice determined the competencies to emphasize in the course on the basis of their expertise and their knowledge of literature pertaining to dairy production medicine. The economics module template, which had been drafted ahead of time, was distributed as a guide. Breakout groups presented their proposals to the group at large for input. By the end of the meeting, the faculty had drafted a curriculum and been assigned modules to expand and complete. The overall goals of the curriculum were as follows:

As a consequence of completing this curriculum, students will:

- Have a better understanding of the roles and responsibilities of veterinarians in dairy food supply veterinary medicine
- Be better prepared to serve the dairy industry

- Be more confident in their ability to serve the dairy industry
- Have a greater conviction to enter careers in dairy-related fields after graduation
- Be successful in obtaining immediate post-graduate employment in dairy-related fields
- Be considered by their employers to have above average preparedness and competencies
- Express satisfaction with the training after 1 year of employment in dairy-related fields
- Retain positions in dairy-related fields and a conviction to serve the dairy industry 1 year after graduation
- Have a minimal exposure to dairy-related vocabulary in Spanish

Curriculum design continued via email and web-based interactions. One of the biggest challenges at the planning meeting had been articulating measurable learning objectives and incorporating student-centered learning strategies. Therefore, the evaluation team created a video that reviewed how to write measurable objectives. The video was distributed to faculty, along with examples of verbs used to measure different learning domains[27] and a scientific review of active learning strategies.[28]

A second on-site planning session was held in May 2012 to review progress and refine module plans using the breakout session approach. At this meeting, the evaluation team also received faculty feedback on questionnaires to be administered to students before and after the course. The questionnaires and their outcomes are described in companion articles.[29,30]

To aid in internal review of the DCE modules, the program coordinators (authors JF, ER) created a Moodle site on which the module coordinators posted syllabi, assessment plans, and instructional materials; an example of a syllabus (for the mastitis and milking systems module) is shown in Box 1. In addition to internal review by course faculty and the evaluation team, external review was sought for a subset of modules. The program coordinators identified content experts to serve as reviewers and provided them with the instructional materials, assessment plans, descriptions of assignments and learning activities, and desired outcomes. External reviewers were given a template that directed them to critique module objectives (with respect to being measurable, aligned with goals, and written from the student perspective); content and pacing (with respect to amount, sequence, organization, clarity, accuracy, referencing, and completeness of content); and teaching methods, learning activities and assessments (with respect to alignment with goals and objectives, balance of student- and instructor-centered techniques, clarity of expectations and assessment criteria, and use of formative and summative assessment). Once the module coordinators responded to reviewers' comments and deemed the modules ready for delivery, materials were transferred to a different Moodle site for students.

CURRICULUM OVERVIEW

The modules and some of the weeks' schedules for the course are laid out in Tables 1–4. Although the order of modules has shifted with each offering of the course, conversational Spanish has always been always taught

Box 1: Syllabus for the Mastitis and Milk Quality Module, Dairy Production Medicine course

Milk Quality Module

Module Goal

Students will develop knowledge of and practical skills in the many facets of milk quality consulting, including; records analysis; on-farm observation and data collection; milking parlor and milking equipment evaluation; and diagnostic, control and treatment programs for mastitis.

Learning Objectives

By the end of this module, the student will be able to:

- Identify and use major sources of information on milk quality, mastitis, and milking equipment evaluation (books, websites, experts, etc.)
- Use and interpret dairy records, milk culture results, creamery reports, and other data sources to formulate hypotheses about milk quality problems and suggest areas for investigation on-farm
- Identify major areas of the dairy cow's environment that can impact milk quality; Evaluate these areas on-farm and suggest improvements
- Understand the difference between milking procedure and routine and how they may be conducted in different types of parlors; know the steps in the milking procedure and the goals for each step
- Evaluate milking routine and procedures on-farm and suggest areas for improvement
- Understand and use the following scoring systems: leg and udder hygiene, teat end hygiene, teat condition scoring
- Identify, name and describe the basic function of the major components of the milking machine
- Explain how milk is removed from the teat during machine milking
- Explain the purpose of pulsation and describe what happens when pulsation fails
- Interpret pulsation test results/pulsation graphs – understand pulsation rate, ratio and phases
- Explain how vacuum is created and regulated in the milking machine
- Recognize causes of vacuum instability, and predict the effect of milking time events on vacuum level in the milking machine
- Select appropriate diagnostic tests to evaluate milking machine performance, understand how these tests are performed and interpret results
- Observe milking time events, cow behavior and teat condition to trouble-shoot potential milking machine problems
- Compare and contrast characteristics of gram-positive and gram-negative mastitis
- Understand the main components of a mastitis control program (such as the NMC 5-Point Plan)

- Understand and implement appropriate control measures for contagious versus environmental mastitis
- Select appropriate individual and herd-level diagnostics for mastitis; advise dairy clients on the use of on-farm culture
- Select appropriate media for culturing different types of mastitis pathogens
- Differentiate among commercially-available intramammary antimicrobial agents on the basis of spectrum of activity and treatment duration
- Identify factors that influence the success of treatment of common mastitis pathogens
- Design farm-specific mastitis treatment protocols
- List factors that should be considered when calculating the cost of mastitis on a dairy
- Use economic analysis of the cost of mastitis and control measures to support recommendations for improving milk quality

Learning Activities

Lectures

Mastitis Biology, Control, Diagnostics, Treatment
Mastitis Economics
Mastitis Records
Milking Routine & Procedures
Milking Equipment Evaluation

Activities:

Milking Equipment Activity (draw and ID components)
Milk Culture Lab
Mastitis Case Activity
Records Computer Lab

Wet Labs:

Parlor observation & data collection: CMT, aseptic milk sample collection, teat hygiene swab, teat condition scoring, milking procedure timing and evaluation, other observations
Equipment testing: claw vacuum, pulsator testing, dry tests

Dairy Visit:

Producer interview
Observation & data collection
Milking equipment testing
Formulate recommendations
Report writing & presentation

Student Assessment

Participation, engagement, and interaction (subjectively evaluated by all participating faculty)
Mastitis case activity – individual score
Post-test score
Presentation of herd report and recommendations

Table 1: Introductory week schedule for the 8-week Dairy Production Medicine course at the National Center of Excellence in Dairy Production Medicine Education for Veterinarians

	Monday	Tuesday	Wednesday	Thursday	Friday
7:30	Welcome and meet dairy managers	Spanish	Spanish	Spanish	Spanish
8:00	Future of the dairy industry and veterinary medicine's role	Communication training	Principles of applied epidemiology and herd level consulting: consulting roles	Preparing presentations	Lactation biology
8:30					
9:00	Communication and personality styles			Mock herd presentation	Evaluating production and components: lecture and computer lab with example herd records
9:30					
10:00			Applying epi principles to monitoring performance, detecting and investigating problems	Dairy herd walk through, observation skills, and summary of findings	
10:30					
11:00					
11:30					
12:00	Lunch	Lunch	Lunch	Lunch	Lunch
1:00	Communication training	Selling, consulting, and motivating change	General use of dairy records: lecture and computer lab	Dairy necropsy: lectures and wet lab demonstration	Student evaluation of a full herd example case: report in groups due after the weekend
1:30					
2:00					
2:30					
3:00					
3:30					
4:00			Orientation to the economics module		
4:30					
Evening	Dinner and orientation to local town				

Table 2: Nutrition week schedule for the 8-week Dairy Production Medicine course at the National Center of Excellence in Dairy Production Medicine Education for Veterinarians

	Monday	Tuesday	Wednesday	Thursday	Friday
7:30	Spanish	Spanish	Spanish	Spanish	Spanish
8:00	Intro to the nutrition week	Types of feeds, byproducts	TMR audits: lecture and practical observations on the dairy	Macrominerals, vitamins, and additives	Making feeding decisions: practical and economic considerations
8:30	Digestive physiology of ruminants	Forages, forage preservation, evaluation, feed analysis			
9:00					
9:30	Nutrition terms and core nutrients				
10:00				Microminerals	
10:30	Introduction to using Spartan ration software; describing the cow				
11:00		Mycotoxins in feed	Herd visits for workup with the focus on nutrition and feeding		Veterinarians working full time as nutritionists for dairies
11:30					
12:00	Lunch	Lunch		Lunch	Lunch
1:00	Dry matter intake, fiber, carbohydrates, fats, energy, then protein and amino acids	Feed and feeding system wet labs		BST and rumensin	Student presentations for the herd visit dairies
1:30					
2:00					
2:30					
3:00	Use Spartan to start to build a milking cow ration: fiber and energy			Spartan lab: balance for protein, minerals, vitamins, additives	
3:30					
4:00		Prepare for herd visit tomorrow			
4:30					

Table 3: Reproduction week schedule for the 8-week Dairy Production Medicine course at the National Center of Excellence in Dairy Production Medicine Education for Veterinarians

	Monday	Tuesday	Wednesday	Thursday	Friday
7:30	Spanish	Spanish	Spanish	Spanish	Spanish
8:00	Managing reproduction and personnel on a large dairy	Repro programs for adult dairy cows	Reproduction herd visits	Impact of health on repro efficiency	Repro management of heifers
8:30					
9:00	Repro parameters			Management of maternity pens and calving	
9:30					
10:00	Computer record assessment of reproduction	Strategies for detecting estrus in dairy herds, non-pregnancy diagnosis, and re-insemination		Managing repro health post-partum and uterine disease in lactating dairy cattle	Understanding bull proofs, designing semen portfolios, and genomic testing and its application
10:30					
11:00					
11:30					
12:00	Lunch	Lunch		Lunch	Lunch
1:00	Economics of reproduction, culling, and repro decision making in developing reproductive programs	AI and estrus detection wet lab		Abortion in dairy cows	Student herd presentations
1:30					
2:00				Use of ultrasound in reproductive management	
2:30					
3:00	Students diagram estrous cycle and discuss impact of exogenous hormones at each stage	Trouble-shooting repro inefficiency		Current status of IVF and embryo transfer	
3:30					
4:00					
4:30					

Table 4: Mastitis and milking systems week schedule for 8-week Dairy Production Medicine course at the National Center of Excellence in Dairy Production Medicine Education for Veterinarians

	Monday	Tuesday	Wednesday	Thursday	Friday
7:30	Spanish	Spanish	Spanish	Spanish	Spanish
8:00 8:30	Introduction to milk quality week and mastitis quiz	Dry cow therapy and heifer mastitis	Parlor evaluation, milking routine and procedures	Herd visits	Economics of mastitis
9:00	Mastitis diagnostics	Milk testing	Milking equip and impact on udder health		Special topics in mastitis control and milking system evaluation
9:30					
10:00 10:30 11:00 11:30	Critical reading of scientific literature: mastitis examples	Milk microbiology and diagnostics lab	Milking equipment evaluation Observation skills: what do you see?		Students work on reports and presentations
12:00	Lunch	Lunch	Lunch	Lunch	Lunch
1:00 1:30 2:00 2:30 3:00 3:30	Continued discussion and mastitis case activity	Mastitis epidemiology, record analysis, prevention, and control	Parlor evaluation wet lab: 1. parlor walk through; 2. milking prep evaluation and teat condition; 3. milking time machine tests	Work on investigation evaluation with faculty	Student herd presentations
4:00 4:30	Protocol assignment	Review herd records and prep for herd visits			

each day of the week, and the week 1 modules have remained constant. The schedule shown in Tables 1–4 is for cohort 2, in which modules were presented in the following order:

- Week 1: Orientation to the Dairy Education Center and course expectations; epidemiology; economics; communication skills and personality types; media training; introduction to herd investigation, report writing and presentations
- Week 2: Disease control and lameness
- Week 3: Pharmacology, drug use, AMDUCA and residue avoidance; food safety; dairy beef
- Week 4: Reproduction
- Week 5: Calves and youngstock
- Week 6: Mastitis and milking systems
- Week 7: Nutrition
- Week 8: Transition cow management; housing and cow comfort; welfare assessment

Before arriving for the DCE course, students were required to complete a series of online training modules in DairyCOMP[b], the predominant dairy recordkeeping software program used in Minnesota and throughout the United States.[31] This effort would have taken a typical student 10 to 20 hours of online effort. A large majority of students completed the work prior to attending.

CURRICULUM DELIVERY

The DCE course incorporated all of the following approaches to learning:

- Lectures
- Independent reading assignments
- In-class small- and large-group exercises (e.g., clicker quizzes, causal web exercise)
- Wet labs in "academic" settings (e.g., microbiology lab) and on the dairy (e.g., insemination lab, forage evaluation, body condition scoring, locomotion scoring)
- Herd visits
- Field trips (e.g., to feed mill, milk processing plant)
- Small group case work-ups culminating in report preparation and presentation
- Videotaped interviews for communication skill training
- Necropsies (made possible by the course being held on a large working dairy)
- Computer labs (e.g., record evaluation, ration balancing, economic analysis)
- Informal dinners and discussions with invited industry experts chosen to serve as role models
- Regular language sessions with a fluent Spanish teacher
- Pre- and post-module tests with formative feedback

Although all modules involved lectures, a great deal of effort was made to incorporate active learning into the course to foster student engagement and promote knowledge retention.

In addition to serving as a repository for syllabi, schedules, and instructional materials (e.g., notes, videos, spreadsheets, PowerPoint presentations, web links) the student Moodle site was a place for instructors to post notices, assignments, and herd records, deliver pre- and post-module tests, and collect student feedback. The site also functioned as a place for students to post questions and upload assignments. In many cases, instructors provided more materials than were used in the course; these materials were intended to serve as resources for students after graduation. The goal was to create an extensive web site with key information and tools that students could access as they dealt with real herd situations once in practice. As such, the Moodle site was kept open to students for at least a year following their graduation.

CURRICULUM EVALUATION AND REVISION

A variety of methods have been used to review the effectiveness of the curriculum and facilitate modification. These include:

- Internal and external review of module content before or between course offerings
- Direct observation of student engagement in learning activities by program coordinators, module coordinators and members of the evaluation team
- Review of student performance on pre- and post-module tests and written and oral assignments
- Voluntary student reviews of modules at the end of each week
- Voluntary student feedback about course content and logistics after 4 and 8 weeks
- Biweekly conference calls between the program coordinators and evaluation team to discuss student and instructor feedback and appropriate responses
- A voluntary 3-question Critical Incident Questionnaire (CIQ) that students completed at the end of the course
- A voluntary questionnaire administered to module coordinators and other major instructors at the conclusion of the first iteration of the course
- A web-based debriefing meeting with module coordinators, other major instructors and the evaluation team in December of 2012
- Student comments made on pre- and post-course questionnaires

The instruments used to gather student and instructor feedback, the pre- and post-module tests used to check learning, and the data and outcomes derived from them are the subjects of companion articles.[29,30,31] In brief, when problems were detected, efforts were made to address them within or between course offerings. The most common problems were unspecified or poorly articulated learning objectives, pre- or post-test questions that were not well aligned with objectives or were poorly worded; excessive content for the time allowed; and limited use of measures to engage students and check learning during lectures. To address the first two, the evaluation team created a template that directly compared pre- and post-test questions with learning objectives. The template enabled recognition of misalignments (objectives not being assessed and test questions not related to stated objectives). When objectives or questions were poorly worded, evaluators suggested revisions. The completed templates and wording suggestions were sent to the program coordinators, who made appropriate adjustments or notified module coordinators. To further help faculty write effective pre- and post-tests, the evaluation team created a good practices document that was circulated to module coordinators and major instructors before the second iteration of the course; the content of this document was adapted from several sources.[32–35] The team also created and circulated a good practices document for engaging students and checking learning during presentations,[35–39] as well as a transcript from an American RadioWorks documentary entitled *Don't Lecture Me: Rethinking the Way College Students Learn*.[40] Feedback from the December 2012 debriefing meeting led to creation of a Lessons Learned document that addressed logistical practices such as frequency of breaks, timeliness of posting of materials on Moodle, length of dinner meetings, and need for timely written and verbal feedback to students. The program coordinators also created a program expectations document that clearly conveyed evaluation criteria to students at the start of the course. All of these efforts enhanced subsequent offerings of the DCE course.

THOUGHTS ABOUT THE DCE MODEL FOR VETERINARY EDUCATION

After having offered the DCE course several times, we offer the following impressions and lessons learned:

- Even with 8 weeks to deliver the curriculum, there was still tension between instructors' desire to (1) maximize content delivery via lectures and notes, and (2) incorporate student-centered learning activities that were perceived to take more time. With these competing objectives, it was challenging to decide what content to include in the modules and how to deliver it. Many faculty were not well versed in how to effectively incorporate active learning strategies.
- Students came to the course with a wide range of experience and prior knowledge, as described in a companion paper.[29] For the first two cohorts, students were admitted if they requested the experience. Therefore, instruction typically had to begin at a fairly basic level, which was not ideal for the more experienced students. For later cohorts, more attention was given to informing students about the level of the course and the demands of the curriculum. Although participants were required to complete online training about the DairyCOMP dairy records software before beginning the course, delivering a lot of basic content prior to the course was considered infeasible because students were fully engaged in rotations at their home colleges.

- Careful selection of students is of critical importance. Many students in the first two cohorts (particularly the fall cohort), were considering working with dairy cattle to some extent after graduation, but were not committed to a career that focused on dairy production medicine. These students often desired experience with individual animal medicine, surgery and reproductive tract palpation, which were not the intent of the DCE course. Because the students' personal objectives did not match the course objectives, they were often less engaged in the course and less willing to make the substantial effort required. Students with little prior dairy experience expressed that they felt lost and overwhelmed by the course expectations and the rapid pace at which the course progressed. These problems were addressed in later cohorts by (1) more explicitly communicating that the course is principally directed at knowledge and application of dairy production medicine not clinical medicine and surgery, and (2) requiring an application that documents the student's experience and career intentions and includes at least one letter of recommendation. This applies even to students from the collaborating colleges.
- Despite the incentive of major federal funding, there was a range of faculty engagement in the processes of curriculum design, web site development, and openness to new teaching and assessment methods. Some faculty who were enthusiastic about participating in the course were not willing to adjust their teaching styles or follow guidelines set forth by the host coordinators or evaluation team.
- Eight weeks is not enough time for students to develop a fully functional set of dairy production medicine skills, just as 8 weeks of clinical rotations is not sufficient for students to develop into fully functional small animal clinicians. There is a trade-off between depth and breadth of coverage in a concentrated course such this. One has to accept that students will not fully internalize knowledge or achieve practicing competency with respect to many components of the curriculum. The best possible outcome may be that students are exposed to many relevant concepts and given the opportunity to gain insight into the knowledge and skills required and techniques that can be applied. Only later, when given opportunities to apply, enhance, and refine their knowledge and skills will they become proficient.
- The web is a very important tool for providing more in-depth information than can be learned during an 8-week course. There is a pressing need to develop good online learning materials for graduates who wish to add to their production medicine knowledge and skills. The web offers the long-term opportunity to provide continuing education and organized access to dairy production medicine resources. Developing web materials takes time and significant resources, but offers a way to capture the knowledge and skills of experts in a more permanent way. Perhaps a consortium of veterinary colleges could agree to collaborate in the development and maintenance of web-based learning materials for dairy production medicine.
- To optimize the quality of comprehensive courses such as the DCE course, faculty and other expert presenters must be attracted from outside the hosting institution. This may prove difficult in the long term without sustainable incentives for their participation. It is one thing to attract experts for the first round of an exciting new concept in veterinary education. Whether the colleges or private businesses from which these talented people are derived will continue to provide support for their participation is uncertain. With a few exceptions, faculty who taught in the curriculum were not compensated. Either they were supported by their academic institution and allowed to teach for free or, in the case of faculty from private industry, did their teaching pro bono. This is likely not a sustainable model.
- Assessment of individual students' higher-level learning and ability to apply knowledge and skills is difficult, even in small cohorts like those admitted to the DCE course (11–18 students/offering). It proved to be very difficult to provide resources and expert faculty guidance to each individual student with respect to herd investigations. Assessment of individual performance was inevitably confounded by the fact that herd visits involved groups of students who shared observations, data, conclusions, and recommendations. It was difficult to tease out a particular student's competence under those circumstances, although across the total span of the course it did seem possible to develop a general ranking of student competency.
- Access to herds is key, but even in a dairy-rich area, it can be hard to find suitable herds that match the teaching objectives and whose owners are willing to allow the intrusion of students who are learning to work at a herd level. While the course setting within the large dairy provided excellent teaching opportunities for many skills, other independent operating dairies were necessary to provide sites to practice herd investigation and evaluation. Within an 8-week period of time, students cannot experience the breadth of environmental conditions and types of dairy enterprises they may encounter in practice, nor can they experience the breadth of problems. Viewed through the lens of traditional clinical training, this is analogous to having a very limited hospital caseload. Other methods of providing breadth of exposure are needed and likely will require web-based presentation. Funding that could pay herds to provide learning experiences may be needed to sustain access to the kinds of herds needed for this type of curriculum.
- Efforts to recruit students from non-collaborating veterinary colleges for this course have proven frustrating. Nearly all veterinary colleges have administrative systems and/or senior student curricular requirements that prevent or nearly prevent students from being away from their home institutions for a course of this type and duration. Despite decades of

asserting that such Centers of Excellence are urgently needed, it is clear that few if any veterinary colleges have actually grappled with what is administratively necessary to make it possible for students to take advantage of an 8-week offering. Financial support for students to attend also is an important limiting factor.

- This kind of course is very expensive to deliver. It seems unlikely that most veterinary colleges will both allow students to attend and contribute funds to pay for the educational effort. It is clear that if such Centers of Excellence are to become sustainable models, then consistent outside funding will be needed.

Many of the challenges faced in this effort have been pointed out by others who have considered the creation of Centers of Excellence.[20–22,25,26] Competing collegiate curricular requirements, student expenses for travel and lodging, course credit transfer, incenting faculty participation, institutional and faculty commitment to their own curricular offerings, funding and tuition allocation, administrative support and general resistance to change are among the issues mentioned. A particularly thorough list of administrative challenges can be found in the paper by Miller and Prasse.[21] The concept of Centers of Excellence has long been discussed and is routinely lauded in theory. Actual implementation of the concept is in its infancy. As one paper noted: "Thus, the reality of regional centers of excellence remains limited by the personal commitment of faculty to the idea."[27]

In the long term, "expanding the concept of Centers of Excellence is a broader-scale solution that will require external resources and cooperation among veterinary schools."[14] In the effort reported here, the creation and operation of the Center did *not* involve extensive participation by or commitment from the collaborating colleges beyond the significant efforts of a select few faculty members. Money did not flow from the collaborating colleges to the host college; in fact, grant money flowed to the non-host colleges as a benefit of participating in course development and delivery and sending students to the course. Thus, this effort did not include any of the potential disincentives that may face some colleges considering sending students to a Center. If the concept of consortial programs is to move forward or is to receive federal funding, some over-arching administrative consent and support from at least several veterinary colleges will be necessary. As things stand, it seems unlikely that such administrative collaboration will be easily achieved. Success of this type of venture will likely depend on both federal and collegiate funding. This challenge at least partly explains why, after 30 years of discussion, there are no long-standing Centers of Excellence for training veterinary students in the United States. The consortial program described in this article formally ended when the federal grant ran out, although many educators who participated in the program continue to do so as part of the University of Minnesota's 8-week dairy production medicine senior rotation. A small number of students from other veterinary colleges (not just the original consortium) and from abroad take part in that rotation.

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Notes

a Moodle open source software, Moodle Pty Ltd, West Perth, Australia, https://moodle.org/

b DairyCOMP, Valley Agricultural Software, Tulare, CA 93274 USA

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