Experiential Learning On-line: CyberSheep

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Introduction

Experiential learning has increasingly been incorporated as an instructional approach. As a teaching strategy that requires the active engagement of students, experiential learning encourages the transfer of factual information to address complex, often ill-structured challenges, which in turn helps develop the learner's expertise related to the given concepts (Kolb and Kolb (2005)). Such activities lead to deeper learning, as well as improved skills in the application of knowledge.

As a form of experiential learning, technology-mediated simulations can provide an authentic context in which learners can apply discipline-specific concepts to solve real-world problems. To that point, simulation programs have been used for decades to facilitate instruction in quantitative genetics (Hocking et al. (1983)). Simulation 'games' in farm animals have often emulated cattle breeding scenarios (Edlund, McGilliard and White (1979); Buchanan, Burditt and Willham (1988)), with existing software updated to incorporate new technologies such as multivariate animal models and marker- and gene-assisted selection, and web-based interfaces (Casellas et al. (2009)). Integration of economic aspects of the farming enterprise into these simulations is the exception.

CyberSheep is a web-based, genetic simulation game designed to allow students experience applying principles in quantitative genetics to a virtual sheep breeding cooperative. It considers both genetic and economic principles. Run centrally at Virginia Tech, teams of undergraduate and graduate students from as many as 11 Universities have played simultaneously, balancing decision-making within their enterprise with that of the overall cooperative. Beyond describing the CyberSheep simulation, the aim of this paper is to assess the learning and perceptions of students participating in its implementation.

Material and methods

Game objective. In CyberSheep, students are challenged to achieve one of two goals: improve market weight while alleviating a genetic disease; or, increase the market value of their flock. This instills a 'friendly' competition among teams, as in practice in cooperative schemes. Teams, usually with 3 members from the same or different institutions, decide which ewes to retain in their flock, and which rams to mate to these ewes. They can offer high genetic merit rams from their flock for use as reference sires, potentially benefitting

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from semen sales. Alternatively, they can purchase artificial insemination (AI) services. Surplus lambs can be sold to market. Teams can buy and sell rams through private barter with other flocks, or purchase a genotype test.

Simulation. CyberSheep is an extension to software of Lewis and Simm (2000), written in FORTRAN. Two correlated traits are simulated (market live weight; litter size). Breeding values for founders are sampled from a bi-variate normal distribution. Offspring are generated from the mean of parental breeding values plus a Mendelian sampling term. Inbreeding coefficients are obtained (Meuwissen and Luo (1992)), with coefficients exceeding 0.125 reducing ewe fertility and lamb survival. A simply-inherited recessive lethal is also simulated, which is independent of the polygenic traits.

Phenotypic values are constructed as the sum of environmental effects, a residual value, and true breeding value. Fixed environmental effects of flock (husbandry), year (season), dam age, lamb sex and rearing type are generated. A permanent environmental effect is sampled for litter size, which is assumed to have a continuous, normal underlying distribution (liability). The number born is defined by threshold values on the liability scale.

At the start of the game, each team is provided with a flock consisting of about 40 ewes, some rams, and their lambs. Each flock has history, several years of previous performance recording yet without any past selection. Flock genetic means may differ due to drift. At the end of each round of play, teams submit their decisions. Data are downloaded. The simulation is run with, as its final step, an across-flock genetic evaluation fitting a bi-variate linear animal model. Complete pedigree and performance data are used in the evaluation. The game web-site is then populated with the new data.

Input parameters can be changed to affect co-variances among traits, size of fixed effects, age of sexual maturity and culling, conception rate and mortality. The dynamics of the cooperative can also be modified: its structure (e.g., number and size of flocks; number of reference sires), its costs (e.g., AI services; semen purchases; genotype tests); and, its earnings (e.g., market lamb value; cull ram prices; semen sales). A game typically consists of five rounds (years) although that can also be varied.

Web-interface. The development environment for CyberSheep is Visual Studio, using SQL Server for database management. The application runs on Windows Server software. It provides utilities for ram and ewe selection, mating assignments, reference sire nomination and election, ram sales and genotype testing. Once logged-in, a team can access the complete production and pedigree data on its flock. Those data can be downloaded into an Excel file for further manipulation and study. A record of financial transactions is also supplied. Plots are provided showing genetic gains achieved for market live weight and inbreeding accrued for the entire cooperative. Only a team’s own flock is delineated on the plot.

Pedagogical methods. An Instruction Manual and two audio-presentations provide background on the principles of cooperative breeding programs, and the mechanics of CyberSheep. However, students are allowed the freedom to explore the game’s many amenities, to discuss the philosophy and technicalities of their decision-making, and to witness the consequences of their team's strategy as the game proceeds. The intent is to allow "learning by doing".

A notable aspect of CyberSheep is its use of teams, working collectively toward a common goal in a realistic problem-based scenario. Through a forum utility in the game, team members can discuss their decision-making exclusively among themselves, or publicly with other teams. A team's success depends on the development of clear channels of communication.

Results and discussion

Figure 1 shows change in true breeding value and inbreeding coefficient over time for 7 teams for one offering of CyberSheep. Teams 'acquired' their flocks in 2009, with the outcome of their selection and mating decisions first appearing in 2010. The 'red' team won the genetic gain competition; it made the quickest annual gain in market weight (+1.4 kg/year) and eliminated the lethal allele in 2013. The 'blue' team won the financial competition with earnings of $23,846. Inbreeding was curtailed the first years of selection with use of rams across flocks. With continued sharing of high merit rams, inbreeding again increased. Such is the case in practice.

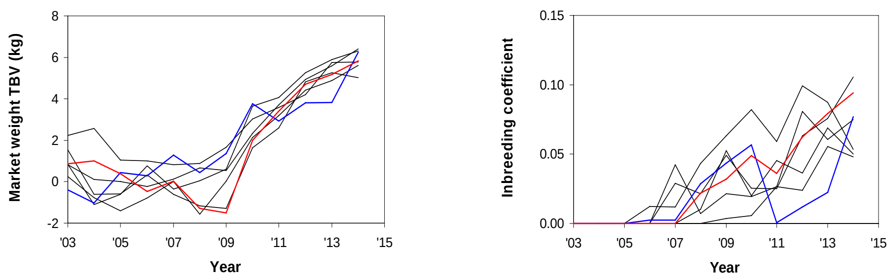

Figure 1: Change in true breeding value (TBV; kg) and inbreeding coefficient over time. Selection began in 2009. Teams in red and blue won the genetic gain and earnings competitions, respectively

Student feedback was collected at the conclusion of each game in order to guide revisions for the enhancement of future offerings. Of 39 survey responses across three instances of the play, 26 respondents (66%) strongly agreed that Cybersheep contributed to their ability to apply genetic principles to make effective breeding decisions. Additionally, 27 respondents (69%) indicated that Cybersheep helped them to gain a broader understanding of co-operative breeding programs in general. Students also provided open-ended reflections on positive aspects of the game. CyberSheep provided opportunity to see breeding strategies and concepts in action, and to experience real trends and issues that are simply not learned from reading textbooks and that take much longer in the real world. One of the primary challenges students faced in playing the game centered on the task of working in teams, particularly when formed across institutions. While some of the issues were logistical in nature, other problems related to the ability of teams to work collaboratively and equitably, also authentic challenges faced in real-world cooperative programs.

Conclusion

CyberSheep has evolved into a unique, technology-enriched learning tool with sufficient flexibility to be incorporated into graduate and undergraduate courses alike, and to reach students that are geographically dispersed.

Driscoll (2002) proposed the idea that learning occurs in context, is active, social, and reflective. To that point, Cybersheep provides the authentic context of an animal breeding cooperative in which students work collaboratively to engage in the activities and decisions that cooperative members must face in real-world situations. Reflection is an inherent part of the game, as the outcomes of breeding decisions drive the teams' genetic progress and influence each round of play. As Morgan (2008) stated, "it is more effective for them to be able to experience the practical effects of different behaviors and strategies in a learning situation than to passively observe them" (p. 35), a statement that is well-supported by Cybersheep's evaluation results and positive student perceptions of this experiential instructional approach.

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