Can on-line training be an effective tool to motivate and support learning in quantitative genetics and genomics?

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Summary

The biological revolution over the past few decades has redefined modern genetics. Society benefits from an ever-increasing understanding of the behavior of genes and their networks. The use of such vast information depends on its integration into a quantitative genetics framework, particularly for its routine incorporation in animal selection programs. However, precisely at a time when there is a growing need for young professionals skilled in quantitative aspects of genetics and genomics, our capacity to train scientists in a global context with such expertise is at risk. Limited funding, geographical distances, time differences, and diverse educational and cultural backgrounds pose technical and curricular difficulties. A solution is to share resources and capacities across-institutions to develop and deliver high-quality instruction to a broad and more diverse audience. One mechanism for doing so is on-line training provided it is an effective tool to support learning. In this paper, two programs – a collaborative multi-institutional graduate curriculum in quantitative genetics and genomics, and a web-based genetic simulation game – are considered as illustrations of effective on-line training. Outcomes of these programs indicate that, with forethought in their implementation, on-line training can be an effective tool to motivate and support learning in quantitative genetics and genomics, and provide opportunity to reach a global audience.

Keywords: experiential learning, on-line training, partnership, graduate education, global opportunities

Introduction

The biological revolution has been compared to the industrial revolution, with caveats that it has happened faster and will have a far greater impact on our lives. Interpreting and using knowledge emanating from this revolution requires unique skills. A tailored educational program in quantitative genetics and genomics that keeps pace with that need, particularly where expertise and resources to provide such training is limited, is our global challenge.

Similar to the rapid developments in genetic technologies, the methods in which we deliver training also is changing. Integrating distance-delivery with experiential learning has been shown to substantially enhance the learning process (Galloway, 2007). Furthermore, it allows engagement of a more diverse and geographically dispersed audience. Yet converting traditional face-to-face course offerings into on-line delivery formats is one of the greatest challenges facing administrators and faculty in higher education (Care & Scanlon, 2001). Perceived obstacles include time requirements, developing effective technology skills for on-line instruction, and concerns over the robustness and academic integrity of distance-
delivered curricula (Rockwell et al., 1999).

One form of experiential learning is technology-mediated simulations where learners apply discipline-specific concepts to solve real-world problems. The use of such simulation programs to facilitate instruction in quantitative genetics is by no means new; it has been in play for decades (Hocking et al., 1983). Simulation games in livestock have historically emulated cattle breeding scenarios (Edlund et al., 1979; Buchanan et al., 1988), with existing software updated to incorporate new technologies such as multivariate animal models and genetic markers, and web-based interfaces (Medrano et al., 2010). Since computer-based, these virtual games can be integrated into distance-delivery programs.

The focus of this paper is to consider a key pedagogical question: can on-line training be used as an effective tool to motivate and support learning in quantitative genetics and genomics. As a step toward addressing that question, the first objective of this paper is to describe experiences with distance-delivery and experiential learning targeted at training tertiary level students in animal genetics in the U.S. I will use two illustrations: (i) an ongoing multi-state, Master’s-degree level curriculum in quantitative genetics and genomics, and (ii) a web-based, genetic simulation game – CyberSheep – designed to encourage students to apply quantitative genetics theory to a virtual breeding program. Secondly, key considerations for establishing a framework to incorporate on-line training into a global initiative to motivate and support learning in quantitative genetics and genomics are introduced.

**Graduate on-line training**

Beginning with four universities in 2007 and expanding to seven in 2012, a multi-state consortium establish an on-line training program designed to integrate advances in animal genetics and genomics into pragmatic agricultural systems. Its target audience is Master level graduate students. Sixteen courses were developed using a common systematic process of instructional design (Gustafson and Branch, 2002; Larson and Lockee, 2014). These courses consider quantitative genetics, statistical methods, and their integration with molecular genetics. Since educational backgrounds differ among students enrolling in the program, it was designed to be comprehensive. It provides both breadth and depth of coverage, and combines theory with application to solve real-life problems. Each course was reviewed by two academic peers and an instructional designer, with that feedback then used to revise content and structure.

The initial development and offering of the program was funded by the USDA-NIFA Higher Education Challenge Grant program (Lewis et al., 2014). In fall 2015, the curriculum was integrated into AG*IDEA (https://www.gpidea.org/program/quantitative-genetics-and-genomics), a national consortium of universities offering on-line courses in agriculture disciplines. That change established a permanent infrastructure for the program, and a mechanism for students to receive formal academic credit. However, since those students who are matriculated at one of the 19 member institutions of AG*IDEA can directly enroll in these courses, access has unfortunately become more limited, particularly to international students.

Since its inception, over 300 students from 34 U.S. universities and colleges, and 5 international academic institutions, have completed over 1,100 course credit hour in the curriculum. Individual courses enrollments have varied from 2 to 37, with as many as 9 students from a single institution.

Summative anonymous feedback was sought from students who completed at least 7 courses in the curriculum. Although response limited (15 students), 87% rated the overall...
quality of the program as either good or excellent, while the remaining 13% rated it as fair. Comments included: “I am glad I had the experience. It is a great step towards the type of collaborative learning we need in higher education, since departments in animal science have gotten smaller and had to cut course offerings and programs for Graduate Students”; “I enjoyed it, this gave me an opportunity to learn and experience aspects of genetics that have always been of interest to me however I was never in the position or location to get training for genetics in applied animal breeding”; “As a distance learner, I got practice on not only lecture contents, but also communication skills.”

As a key outcome, this curriculum has provided a high quality, customized program to fulfill academic and industry needs for individuals with professional skills in quantitative genetics and genomics. Importantly, that knowledge base is central to the application of genomic technologies in commercial animal agriculture.

**A tool for experiential learning: CyberSheep**

CyberSheep is a genetic simulation game designed to provide students with an experience of applying quantitative genetics theory to a virtual sheep breeding cooperative. A unique attribute of this computer game is that it includes financial elements: students are challenged to consider economic as well as genetic factors that impact real-life farming systems. I first launched CyberSheep in 2003. Since then it has undergone substantial upgrade with development of a purpose-built web interface. It is run centrally from the University of Nebraska-Lincoln, with typically 300 undergraduate students from five universities playing simultaneously each academic term.

Two polygenic traits and one disease locus are modeled. 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. Teams decide which ewes to retain and which rams to mate to these ewes. They can purchase artificial insemination services from rams in other flocks to increase the genetic merit of their own flock more quickly. They also can buy and sell rams through private barter with other flocks. Teams may purchase a genetic test to determine whether an animal carries the genetic disease. These choices mirror the decision-making in real-life breeding programs, and test students’ aptitude to synthesize and apply their knowledge of genetic principles to novel circumstances (Lewis et al., 2010).

Anonymous evaluations were sought from students on a regular basis, most recently in 2016. That year, 255 students completed the survey. When asked if CyberSheep reinforced (extended) their course learning in animal breeding and genetics, 69% responded yes and 22% responded somewhat.

Cybersheep has evolved into a unique, technology-enriched learning tool able to reach students that are physically distant. Students experience the effects of different behaviors and strategies in an authentic, practical context. Since the outcomes of breeding decisions drive the teams’ genetic progress, and that of the overall cooperative, reflection, an imperative element in any educational process, is an inherent part of the game. Furthermore, student perceptions of this instructional approach have been quite positive.

**A global opportunity?**

There clearly is a global need for advanced training in quantitative genetics and genomics. How might on-line training contribute? A key way is by providing the mechanism to share resources and capacities across-institutions to develop and deliver high-quality instruction to
traditional and non-traditional students internationally. Such cohesion can only be achieved through a global initiative able to connect with and synchronize students and instructors dispersed over vast distances, and bridge diverse cultural and traditional ways of learning and instructing. Key considerations for establishing the framework for such a partnership include i) program infrastructure and administration ii) curriculum content, quality and accreditation, and iii) mentoring.

**Infrastructure and administrative requirements**

For an on-line curriculum to serve a geographically dispersed audience, there are infrastructure and administrative requirements. For instance, participants must have reliable access to high-speed internet and computational resources, including software and technical support, to develop the analytical skills to handle often large data. There must also be the incentive for experts, both in industry and academia, to devote their time and enthusiasm to develop and instruct distance-delivered courses. That necessitates administrative recognition and encouragement to prioritize such efforts as a significant and valued aspect of a career path. Furthermore, sustainable financial support is necessary. Faculty time and effort will need to be compensated. There will be administrative and organizational costs to be paid. With a global audience of students, undoubtedly with varying financial resources at their disposal, tuition and other course fees will need to be supported. For the long-term continuity of an on-line curriculum, realistically confronting infrastructure and administrative challenges upfront seems paramount.

**Curriculum content, quality and accreditation**

Defining the content of a quantitative genetics and genomics curriculum is comparatively straightforward. Existing face-to-face programs provide a sensible starting point, which can be built upon by seeking feedback from discipline experts as illustrated earlier (survey). Including industry leaders in that discourse is undoubtedly key to ensuring the relevance of the curriculum. Regular re-evaluation of the content of the program is also important. Methods to ensure the quality and rigor of the courses offered will need to be developed, include formal rubrics and course peer review. Such will be particular key if the curriculum was to provide academic credit toward a certificate or degree. A system for assessing student prerequisite knowledge at entry to the curriculum also would be needed. Approaches for collecting summative and formative feedback from students, including evaluation of their knowledge retention, should be established.

**Mentoring**

The curriculum should serve students of different educational and cultural backgrounds. Developing a social and instructional support network to maintain student motivation and engagement would be essential. This may entail blending face-to-face contact, such as short-courses, student exchange programs, and virtual recitation sessions, with the on-line training. This would be particularly important early in the curriculum. Students could be paired with a faculty advisor to provide academic support and on-going mentorship. A framework to support students’ lifelong learning once completing the curriculum should also be considered.

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List of References


