INTRODUCTION

Agriculture is an interdisciplinary field of study that relies heavily upon biology to address complex issues in health, nutrition, reproduction, and wellbeing. Traditionally, biology education has benefited from the integration of both academic and applied concepts; however, the interdisciplinary nature of modern biology imposes academic hurdles in establishing conceptual and physical competencies. Modern advances in research and technology permit greater understanding of microbial mechanisms involved in nutrition, yet it is increasingly difficult to disseminate complex concepts such that students, stakeholders, livestock producers, and the general public can make meaningful connections and apply the new information to relevant situations.

Web-based learning environments integrate student engagement, autonomous learning, and educator support via the Internet (1). Web-based learning technologies contribute to scholarship and outreach by allowing learners to access evidence-based information in an accessible format. Evaluations of Web-based learning demonstrate its promise, as learners have been shown to score higher in student engagement measures and to utilize deeper learning approaches, including critical thinking and reflective learning (2). Even for adult and non-traditional learners, Web-based educational platforms combined with social interaction with instructors or peers have proven to be important in enhancing learning and participation (3). The use of Web-based interaction also enhances learning, retention, and accessibility of information that may otherwise not be available to particular audiences (4). Web-based learning tools aid in the creation of courses that enhance student engagement through traditional classroom pedagogies and online educational technologies (5). These digitally mediated tools permit education beyond the constraints of lecture-based approaches.

PROCEDURE

Concept, implementation, and content entry

The overall goal of this educational tool was to allow learners to access new information in a novel and interactive way, while also supplementing existing methods of knowledge dissemination. For this tool to effectively impart useful knowledge, it was critical to implement an easy-to-use, interactive interface housed within SharePoint. SharePoint is a common content management system that can be modified by IT professionals to facilitate educator input.

The educational tool, which features a different microbe each month, consists of five primary components: 1) the name of the microbe, 2) a brief overview of the microbe, 3) a main image depicting the model animal for the microbe, 4) hotspot images, and 5) the name and photo of the author of the monthly installment (Fig. 1). Featured microbes were theme-based, covering species that play critical roles in production agriculture and nutritional function based upon the educators’ interests. Different microbes within the gastrointestinal tract of varying animals were updated and discussed monthly, along with timely information regarding livestock management.

An easy-to-use dashboard containing a styled list allows educators to enter information into the Web interface (Fig. 2A). The name and overview of the microbe are critical in cultivating interest and thus were written without use...
of technical jargon and rhetoric (Fig. 1). The main image depicted the model animal for the featured microbe, which varied depending on the monthly feature, and permitted the educator access to a wide range of species and topics. The main image contained hotspot images, which pinpointed the location/environment/organ of the microbe of interest. Hotspot images and content were loaded by the educator into the Web interface dashboard, and hotspot locations on the main image were selected at this time (Fig. 2B). The hotspot content box contained images as well as text regarding the microbe in that location/environment/organ. Such information included function, symbioses, relation to nutrition, or positive/negative attributes relating to habitation. To increase functionality, an archive option was developed to permit learners to return to and retrieve information from past monthly features through an easy-to-use navigation bar (Fig. 2A). To view the interface and user interaction, please visit https://rumenmicrobes.utk.edu.

User recruitment, interaction, and reception

For self-directed learning, targeted users included undergraduate and graduate students, stakeholders, county agents, and the general public. The URL of the website was circulated to them via social media, email listservs, course content, extension publications, and personal interaction. Within college-level courses, the Web-based tool was used to illustrate roles of microbes within gut function and disease states. It provided students with a visual representation of theoretical concepts, targeting different learning styles and associative learning processes. For example, this tool was used to introduce the archaeal microbe *Methanobrevibacter ruminantium* and introductory concepts to a graduate Ruminology course.

The learning tool was developed to focus on a different concept of nutritional microbiology each month, encouraging regular user access to the website. Initially hooked by an attractive overview of the featured microbe, users then interacted with the interface to cycle through the hotspots and read additional information (Fig. 3). Discussions with users indicated the tool was simple to use, accessible to all potential users, and included complex information related to increasing production efficiency in an easy-to-understand manner. The content of the tool can be modified by each educator to address user-experience input.

CONCLUSION

Overall, this interactive, Web-based tool provides a novel approach to presenting microbiology and biology concepts in an accessible, applied manner in classic academic and non-traditional learning settings. This tool could be incorporated into student recruitment, extension programming, adult or youth educational events, or other STEM outreach efforts, such as field days or booth
displays, to aid in dissemination of basic science research and its impact on production agriculture and daily life. Additionally, the interface allows the educator to feature various animal and microbial species and makes the tool available across various platforms.

ACKNOWLEDGMENTS

Special recognition is warranted for Michele Wilson and Billy Williams from the University of Tennessee Institute of Agriculture Information Technology Services for their assistance to the Animal Science Department in developing this interactive, Web-based learning tool. The authors declare that there are no conflicts of interest.

REFERENCES

1. Storey MA, Phillips B, Maczewski M, Wang M. 2002. Evaluating the usability of Web-based learning tools. Educ Technol Soc 5(3):91–100.
2. Chen PSD, Lambert AD, Guidry KR. 2010. Engaging online learners: the impact of Web-based learning technology on college student engagement. Comput Educ 54(4):1222–1232.
3. Bayrak T, Bahadir A. 2017. Understanding student perceptions of a Web-based blended learning environment. J Appl Res Higher Educ 9(2):577–597.
4. Patel C, Lei Y, Liu L, Vernica R, Fan J, Short B, Liu J, Simske SJ. 2017. Learning in the 21st century cyber-physical age. APSIA Trans Signal Inform Processing 6:e12.
5. Howard JM, Scott A. 2017. Any time, any place, flexible pace: technology-enhanced language learning in a teacher education programme. Austral J Teach Educ (Online) 42(6):51.