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Prairie Project on Zooniverse: citizen science and inquiry-based learning for promoting rangeland literacy

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Abstract

The Prairie Project aims to promote pyric herbivory and mixed species grazing as climate-smart agricultural practises for sustaining livestock production and other ecosystem services of rangelands in the Great Plains. Key to fulfilling such a shift of management paradigm is effectively engaging land managers and professionals, future professional and decision makers, and the public through integrated research, education, and extension efforts. Leveraging citizen science as an effective tool for research and education and outreach through crowdsourcing, we have been developing citizen science projects on the Zooniverse platform for engaging secondary and undergraduate students as well as the public, based on research data collected at our research and demonstration ranches across the Great Plains. In one of these projects, students and the public engage in identifying animal species and their activities as captured on camera-trap photographs from a research ranch. The data generated are essential for studying the spatial and temporal distributions and behaviour of livestock and wildlife in different vegetation communities and with different burn histories. Crowdsourcing the data classification also presents educators with a platform for designing and implementing high-impact learning activities in classrooms and extension programs. Importantly, this also allows us to reach a broader and more diverse audience outside the traditional range management and ecology community. We have developed and implemented learning activities in an introductory ecology course at a research university and are developing learning activities for additional educational settings. During the last two years, over 950 students have engaged in this Zooniverse project as part of an authentic inquiry project to explore the effect of fire on animal distribution and behaviour in different vegetation settings and developing critical thinking and communication skills. Assessment data show that these experiential learning activities resulted in significant gains in understanding the scientific practice and rangeland literacy.

Introduction

The future of productive rangelands requires management practices that promote conservation of systems and education on the importance of rangelands for agricultural products and ecosystem services. The expansion of woody plants into grasslands of the North American Great Plains is a threat to the productivity, biodiversity and function of these rangelands (Archer et al. 2017, Londe et al. 2022). A secondary concern is the challenges presented by a growing urban population making policy decisions affecting rangelands (Sayre 2023).

The Prairie Project is a collaboration among researchers and extension specialists from the University of Nebraska-Lincoln, Oklahoma State University, and Texas A&M University. The project aims to increase the ecological and economic production of Great Plains rangelands by combatting woody plant encroachment with pyric herbivory and multispecies grazing. As part of the research into the effects of these treatments, we have

placed camera-traps on a research ranch in Texas to record the movements of livestock and wildlife. To assist us in classifying the animals and their activities, we have employed the public through the citizen science platform Zooniverse. Photographs are grouped into six categories based on the locations' burn status (burned or unburned) and vegetation community (herbaceous-dominated, small woody-dominated, or large woody-dominated).

Authentic inquiry-based learning engages students by allowing them to investigate real-world, open-ended problems using critical thinking and the research process (Crawford 2000, Herrington and Kervin 2007, Krajcik and Blumenfeld 2006). To this end, we have developed a Zooniverse-based authentic inquiry activity for students of an introductory ecology class at an R1 university. We investigated the effectiveness of this activity by analyzing students' self-assessments on interest, ability, and knowledge of ecology and the scientific process (Wu et al. 2021).

Methods

The activities of this inquiry-based project were given to students of an introductory ecology course titled 'Fundamentals of Ecology' at Texas A&M University in the fall semesters of 2022 and 2023. This sophomore-level class has enrolment of 400 – 500 students. During the first week, students were taught the concepts of pyric herbivory and multispecies grazing and their use in combatting woody plant encroachment and increasing quality forage production. They learned about the study site and were assigned 100 photo classifications through the Prairie Project Zooniverse page. Students completed a survey by rating themselves on the following prompts on a Likert scale of 1 (very low) to 5 (very high): 1) interest in ecology, 2) ability to formulate a testable hypothesis, 3) understanding of the research process, and 4) ability to evaluate a scientific report. Working individually, students began identifying patterns in the photographs during the second week to develop a testable hypothesis and design the needed methodology to gather evidence to test their hypothesis. Students collected and analyze their data and submit a report during week 3. Peer reviews were conducted during the fourth week followed by revisions and final submissions during the fifth week. The project concluded with students again rating themselves on the same survey.

To test students' self-perception of learning, we analyzed pre-project and post-project responses to survey questions using a Wilcoxon signed-rank test. We evaluated effect size using Cliff's delta with the measures of $\delta = 0.11$, 0.28, and 0.43 to indicate small, medium, and large effect sizes, respectively (Vargha and Delaney 2000). Additionally, we applied Wilcoxon signed-rank test for each survey question by student categories. These groupings were male and female students, upperclass and lowerclass students, underrepresented minority students (URM) and other students (non-URM), and students taking the course as a degree requirement (major) or science elective (non-major). For purposes of this study, first- and second-year students were classified as lowerclass and students in their third year or beyond were classified as upperclass. Students from university departments of ecology and conservation biology; rangeland, wildlife, and fisheries management; environmental studies; landscape architecture; and recreation, park, and tourism sciences were required to complete this course. Finally, Hispanic, black, American Indian, mixed race or ethnicity, and international students were classified as underrepresented minorities. We used Mann-Whitney U-tests to detect differences in learning gains (calculated as pre-survey response subtracted from post-survey response) between male and female students, upperclass and lowerclass students, URM and non-URM students, and major and non-major students. Again, we evaluated effect size using Cliff's delta.

Results

A total of 568 students consented to participating in our study during the autumn 2022 semester ($n = 325$) and the autumn 2023 semester ($n = 243$). Based on our demographic groups, there were 231 male and 337 female students and 199 URM and 369 non-URM students. There were 248 upperclassmen, 320 lowerclassmen, 369 major students, and 199 non-major students.

Overall, students' interest in ecology did not differ between pre-survey and post-survey responses ($W = 3572.5$, $p = 0.9112$). We detected significant differences in students' ability to formulate a hypothesis ($W = 5687$, $p <$

0.0001), understanding of the research process (W = 2737, p < 0.0001), and ability to evaluate a scientific report (W = 5353.5, p < 0.0001). Effect size for these responses were medium (δ = 0.387), large (δ = 0.551), and medium (δ = 0.429), respectively.

When broken into groups, we again did not detect a difference between pre-survey and post-survey responses for students' interest in ecology (Table 1). Differences were detected across all groups for the remaining survey responses. All groups exhibited a medium effect size for hypothesis formulation except male students with a small effect. A large effect size was observed across groups for understanding the research process. Finally, all groups exhibited a medium effect size for evaluating scientific reports except female students with a large effect.

Table 1. Differences in students' self-perception of learning before and after participation in an authentic inquiry project as tested by Wilcoxon signed-rank test (W) with effect size measured by Cliff's delta (δ).

Student Group	Interest in ecology			Ability to formulate a hypothesis			Understanding of the research process			Ability to evaluate a scientific report		
	W	*p*	*δ*	*W*	*p*	*δ*	*W*	*p*	*δ*	*W*	*p*	*δ*
Male	1695	0.858	0.001	1735.5	<0.001	0.315	652.5	<0.001	0.538	1082	<0.001	0.357
Female	3234	0.754	0.009	893.5	<0.001	0.437	676	<0.001	0.558	1577	<0.001	0.480
URM	1535.5	0.676	-0.003	734.5	<0.001	0.386	297.5	<0.001	0.556	526.5	<0.001	0.466
Non-URM	3469.5	0.643	0.010	2340.5	<0.001	0.388	1222	<0.001	0.548	2535.5	<0.001	0.409
Upperclass	1345.5	0.434	0.021	1386.5	<0.001	0.356	689.5	<0.001	0.511	1268	<0.001	0.388
Lowerclass	3615.5	0.622	-0.006	1405.5	<0.001	0.416	648	<0.001	0.581	1389	<0.001	0.462
Major	4623	0.804	-0.002	2380.5	<0.001	0.400	1116	<0.001	0.572	2691	<0.001	0.431
Non-major	905	0.582	0.022	711.5	<0.001	0.364	358.5	<0.001	0.512	458.5	<0.001	0.427

None of the results of the Mann-Whitney U-tests showed a significant difference between learning gains of any of the groups across all 4 survey responses.

Discussion

Assessment showed that participation in this authentic inquiry project promoted students' self-perception of learning the scientific research process. This methodology has been shown to promote knowledge retention and academic performance in the STEM fields, enhance student engagement and motivation, supports development of self-regulated learning, and increases student confidence in their academic abilities (Savery 2006, Zimmerman 2002). Furthermore, inquiry-based learning promotes systems thinking in ecology and can inspire students to engage with ecological issues (Gormally et al. 2009, Tanner 2009).

By using our citizen science project on Zooniverse, we were able to provide students with exposure to actual data from research in a rangeland setting. The course curriculum provided a wide-range of students with lessons in rangeland ecology, management practices, and problems facing rangelands. The majority of the students taking this course do not study rangeland ecology and management nor come from rural backgrounds or demographics of past rangeland managers. Thus this is an important outreach interface. Rangeland literacy can promote positive outcomes by educating voters and future policy-makers whose decisions often affect the stewardship of these lands (Launchbaugh et al. 2012). Two noteworthy challenges to current rangeland curriculum include shifting demographics and organizational shifts within university programs (Tanaka et al. 2012). Our results indicate that we were able to provide rangeland literacy across all demographic groups from an introductory ecology course not housed within a rangeland ecology and management department.

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References

Archer SR, Andersen EM, Predick KI, Schwinning S, Steidl RJ, Woods SR (2017) Woody plant encroachment: causes and consequences. In 'Rangeland Systems: Processes, Management and Challenges'. (Ed. D Briske) pp. 25-84. (Springer, Cham, Switzerland).

Crawford BA (2000) Embracing the essence of inquiry: new roles for science teachers. *Journal of Research in Science Teaching* 37, 916-937.

Gormally C, Brickman P, Hallar B, Armstrong N (2009) Effects of inquiry-based learning on students' science literacy skills and confidence. *International Journal for the Scholarship of Teaching and Learning* 3, 16.

Herrington J, Kervin L (2007) Authentic learning environments. *Education and Information Technologies* 12, 219-235.

Krajcik J, Blumenfeld P (2006) Project-based learning. In 'The Cambridge Handbook of the Learning Sciences'(Ed. RKM Sawyer) pp. 317-334. (Cambridge University Press).

Launchbaugh K, Bestelmeyer S, Hyde G (2012) Rangelands in the classroom: increasing rangeland understanding of students and teachers. *Rangelands* 34, 49-52.

Londe DW, Cady SM, Elmore RD, Fuhlendorf SD (2022) Woody plant encroachment pervasive across three socially and ecologically diverse ecoregions. *Ecology and Society* 27, 11.

Savery JR (2006) Overview of problem-based learning: definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning* 1, 9-20.

Sayer NF (2023) Sustaining rangelands in the 21st century. *Rangelands* 45, 53-59.

Tanaka J, Call C, Abbott L, Hickman K (2012) Teaching to learn and learning to teach: education in rangeland ecology and management. *Rangelands* 34, 3-5.

Tanner KD (2009) Reflections on the role of inquiry in science education. *Science Education* 93, 1-20.

Wu XB, Sandoval C, Knight S, Jaime X, Macik M, Schielack JF (2021) Web-based authentic inquiry experiences in large introductory classes consistently associated with significant learning gains for all students. *International Journal of STEM Education* 8, 31.

Zimmerman BJ (2002) Becoming a self-regulated learner: an overview. *Theory into Practice* 41, 64-70.