

**Science, Poetics, and Immersive Field Ecology: Generating New Knowledge
Through Interdisciplinary Inquiry**

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Abstract. Complex global challenges and declining scientific literacy demand novel approaches to engaging students with science and the natural world. While evidence supports integrating creative and scientific modes of inquiry, these approaches are often separated in undergraduate education. We designed Ecology Through the Writer's Lens (ETWL) to allow students to explore an ecosystem of critical importance, the tall grass prairie, through an interdisciplinary field experience. Co-taught by Biology and English professors and open to students of all majors, ETWL leverages classroom activities to prepare for and process the immersive field experience over the course of one semester. Field-based exercises include natural history observations, hypothesis building, experimental design, analysis of the literature, and creative/reflective writing. Learning was assessed through multiple assignments, including a final creative project that spanned diverse writing genres. Students met and exceeded expectations with respect to course objectives. Non-science majors learned how scientific knowledge is generated; science majors learned how creative approaches can open new pathways for exploration. Many students overcame fear of natural spaces. Several students independently engaged with tall grass prairie in post-course activities. We conclude that interdisciplinary approaches to field-based inquiry can generate transformative experiences, even when the immersive component is short-term and close to home. ETWL provides one model by which different modes of inquiry can be blended to enhance student appreciation of science, literature, and the environment.

Keywords: Human-nature relations; STEM education; STEAM education; interdisciplinary education; transdisciplinary education; experiential education

In a time of global challenges such as climate change, large scale habitat destruction, and emerging infectious diseases, we face a critical need to expand the understanding of science while strengthening connections to nature. Quantitative scientific knowledge provides the foundation for informed decision-making, but perspectives from the arts and humanities often allow a broader, more effective context for engaging with the environment (Jacobson et al., 2007; Jacobson et al., 2016; Swanson et al., 2008). Fostering a creative, interdisciplinary mindset in the context of science education can produce visionary innovators needed to solve complex problems (DeHaan, 2011; Madden et al., 2013; Mueller et al., 2014; Scheffer et al., 2015; You, 2017). At the same time, introducing non-science students to scientific disciplines through the creative lens can cultivate a deeper understanding of scientific concepts (Gray & Thomson, 2016; Jacobson et al., 2016). We set out to integrate scientific and literary modes of inquiry in a semester-long undergraduate course, Ecology Through the Writer's Lens (ETWL).

ETWL allowed students from diverse backgrounds to collaborate in a focused, interdisciplinary exploration of the natural world. This model helped students develop an appreciation for the scientific process, creative literature, and wild spaces. Implemented close to our home campus with minimal resources, ETWL offers a basic structure for interdisciplinary education in science and creative literature that could be adapted to different institutional and student body needs.

Creative and scientific modes of inquiry form complementary aspects of the relationship between humans and their environment. Yet often in undergraduate education, these are separated by discipline and not allowed to meet on common ground. Integrating science with the creative arts, often referred to as “STEAM” education, has been shown to enhance learning and strengthen scientific creativity in multiple contexts (Brown, 2015; DeHaan, 2011; Gray & Thomson, 2016; Jacobson et al., 2016; Madden et al., 2013; Scheffer et al., 2015). At the same time, use of creative arts to teach science can facilitate a greater appreciation of natural systems and scientific modes of inquiry (Jacobson et al., 2016; Swanson et al., 2008). Much of the conversation around STEAM education focuses on the arts as a path for inspiring creativity within the sciences (e.g., Brown, 2015; DeHaan, 2011; Liao, 2016; Madden et al., 2013; Pollack & Korol, 2013; Taylor & Taylor, 2019). It is important, however, to respect the creative arts as a discipline rather than as a mere set of heuristic tools in service of science education (Bequette & Bequette, 2012; Liao, 2016). With respect to ETWL, we sought to give two subject areas, ecology and creative literature, equal footing throughout the course, integrating them through direct exploration of an ecosystem to enhance and enrich learning across both disciplines. This model followed a more classic definition of interdisciplinary education (Cone et al., 1998, as cited in You, 2017) that has been successfully implemented in other contexts (Gray & Thomson, 2016; Jacobson et al., 2016). In addition to on-campus activities, ETWL included an immersive field component that served as both a laboratory and a writer’s workshop. Working collaboratively, students collected data, generated hypotheses, and created new meanings through direct observation and the written word. They also crafted a creative project based on their field experience.

ETWL was inspired by the H. J. Andrews Experimental Forest Long Term Ecological Reflections program (Swanson et al., 2008). Designed to complement the National Science Foundation’s Long-Term Ecological Research (LTER) program, Andrews Forest Reflections seeks to advance understanding of the natural world by enhancing collaboration between the sciences and the humanities. The program sponsors immersive workshops designed to engage ecologists, creative writers, and philosophers in the task of building and communicating ecological knowledge (Swanson et al., 2008). In the summer of 2011, one of the authors participated in an Andrews Forest Writers Residency. Based on that experience, we developed ETWL to offer our students a similar interdisciplinary experience as part of their undergraduate degree program.

From the course inception, we wanted to make ETWL available to students from all majors and professional tracks. To achieve this, we took advantage of an existing framework within the core curriculum of our home institution: Interdisciplinary

Studies (IS) courses. Taught by faculty from two or more disciplines, IS courses challenge students to consider the strengths and limits of disciplinary knowledge as well as integrate, synthesize, and communicate interdisciplinary knowledge (Avila University, 2020). IS courses are designed to illustrate why certain challenges warrant interdisciplinary examination and how each discipline contributes to the process of understanding and resolution. Our university has a decades-long history of IS courses with the basic model persisting through multiple revisions of the core curriculum. This provided an excellent context within which to implement ETWL.

To facilitate direct engagement with the natural world, we took the students to Konza Prairie Biological Station, about a two-and-a-half-hour drive from our Midwestern campus. Although our campus occupies a region characterized by the interface between deciduous forest to the east and prairie to the west, many of our students start the course with minimal knowledge of prairie as an ecosystem of local and global significance. Prairie dominates the Great Plains, with a natural range that extends over 3.5 million square kilometers from central Texas into southern Canada (Savage, 2011). It is estimated that 96% of North America's original prairie has been altered or destroyed, much of it for agricultural use (National Park Service, 2020). Konza Prairie sits in the Kansas Flint Hills and represents one of the best-preserved tall grass prairie remnants in the United States. The station is a Long Term Ecological Research (LTER) site maintained by Kansas State University and is equipped to support overnight stays by researchers and small groups.

One of our questions going into ETWL was whether a field site close to home could generate a transformative field experience in a short amount of time. A body of literature supports the transformative nature of international field experiences (Gastreich, 2002; McLaughlin & Johnson, 2006). However, many students cannot take advantage of long-distance travel for a variety of reasons. As designed, ETWL could be adapted to a variety of wilderness sites worldwide, and in the planning stages, we did consider international destinations. However, we hoped that by choosing a location and ecosystem close to home, we could provide a valuable transformative experience for a broad range of students.

ETWL had three primary learning objectives that we sought to achieve by giving students first-hand experience in both the scientific and creative processes while immersed in the prairie ecosystem: (1) explore how scientific knowledge is generated and use that knowledge to inspire creative expression, (2) articulate how creativity contributes to the process of science, and (3) describe how both paths of exploration allow us to better understand and interact with our natural environment. Within our primary learning objectives, we had several goals pertinent to scientific and creative/literary aspects of the course (see Table 1 below).

Table 1

Ecology Through the Writer's Lens Learning Goals

Scientific Interpretation	Creative and Literary Interpretation
<ul style="list-style-type: none">○ Acquire a foundation of knowledge about the tall grass prairie ecosystem.○ Generate hypotheses based on detailed quantitative and qualitative observations.	<ul style="list-style-type: none">○ Develop and strengthen writing skills.○ Explore the central role of metaphor in understanding our world and ourselves.

Note: Learning goals were embedded within the larger course Learning Objectives, as discussed in the Introduction.

Course Structure

We implemented ETWL in three stages. Pre-trip preparation included class meetings to provide critical information and set the stage for our field experience. Experiential learning in the field consisted of intensive activities in residence at Konza Prairie Field Station. Finally, post-trip integration included follow-up class meetings and critical assignments to help students process the experience. Here we describe each of these stages in detail.

Throughout the semester, the biology professor led science-related activities and the English professor led creative and literary activities. However, both professors were present for all course events. Moreover, both professors participated in discussion of all course material. In this way, each professor brought the lens of their own discipline to bear on material presented by the other professor. By actively engaging each other and the students in cross-disciplinary discussion, we strived to show by example how professionals from different backgrounds can, through mutual respect and open discussion, find common ground.

Pre-requisite Student Knowledge

As with all IS courses at our institution, students needed to have completed their foundation courses (one semester each of English composition, communications, and college-level math) to enroll. Advanced study of biology or English was not required. Students enrolled for a variety of reasons. Some had enjoyed previous courses with the same professors or had an interest in creative writing or natural history. Others enrolled out of a simple need to fill the IS requirement for their degree. Every semester attracted a new and fresh mix of disciplinary backgrounds and interests. Because of the diversity of student backgrounds, well-conceived pre-

trip activities that accommodated a wide range of skills and expertise were necessary to prepare them for the best outcomes.

Pre-Trip Preparation

We met three times before the immersive trip. Our first classroom event was an organizational meeting. We followed up with two formal lecture periods, one that focused on scientific interpretation of the prairie and a second that focused on creative and literary interpretation.

Organizational Meeting

As part of the course overview, we provided basic logistical information for the field trip. This included confirming dates of travel, clothing, and equipment needs, and organizing the group into cooking and cleaning crews. We also provided time for individual introductions and questions.

This first meeting concluded with a low-stakes, in-class writing assignment. One of the most informative prompts we have used was “What scares you about the field trip?” Their often-surprising answers were invaluable. Some students had lived only in the urban core with little exposure to the natural world beyond a city park and held fears for their physical safety. In addition, many students, especially science majors, admitted fear of creative writing. Knowing their comfort level early in the course helped us build a supportive environment for everyone. This first writing assignment also benefitted students by encouraging them to think and write reflectively, an important component of interdisciplinary study. Finally, reviewing their responses allowed us to assess student writing skills and anticipate where additional help might be needed.

Scientific Interpretation

The primary biology textbook for this course was *Prairie: A Natural History* by Candace Savage (2011). Savage’s narrative was well-suited because the author (1) collates a tremendous amount of scientific information about the prairie in a single volume and (2) relates this information in language accessible to both science and non-science majors. Thus, the textbook achieved a dual purpose of providing a scientific foundation while illustrating one modality—natural history writing—that can result from creative interpretation of the prairie.

Prior to class, students read the first three chapters of Savage (2011). These chapters cover the geological history of the Great Plains, current climate patterns, and the unique adaptations of grasses (family Poaceae). Take-home points from the textbook were reviewed through formal lecture and group discussion. In addition, we introduced the unique qualities of our destination, Konza Prairie in the Flint Hills, within the larger context of the Great Plains.

Creative and Literary Interpretation

The second lecture period focused on students' interactions with creative literature—a collection of short essays and both canonical and contemporary poems. The essays we selected, spanning a 40-year period, were chosen in part for their range of tones from the contemplative to the playful. This broad cross-section (which we expanded with odes in the field) served several purposes. For one, students benefited from realizing that creative literature can engage nature and science in a variety of forms; thus, they need not panic for fear that they would be required to write sonnets if they were more comfortable with essays. Additionally, given many students' limited exposure to quality literature, providing an array of different genres and styles increased the possibility that each student would discover a piece that resonated with them, even if they were not already familiar with that particular form. We opted not to include novels, as the course format was more conducive to studying shorter pieces, and we wanted to concentrate on forms in which students could successfully write at semester's end.

Some texts were chosen that would tie directly to students' upcoming field experiences. We did not share this information with students during the classroom meeting as we knew that allowing "aha" moments to emerge organically in the field creates more powerful connections for students than having them predicted beforehand. For example, during a night walk at Konza Prairie, our students had the opportunity to strike flint together and create sparks. This usually resulted in at least one student excitedly recalling Rossetti's last line, "But a flint holds fire!" Students clearly enjoyed discovering connections between literary readings and field experiences; such moments also helped them appreciate that, although interdisciplinary, this course was as thoughtfully constructed as the discipline-specific classes to which they were accustomed.

Students completed the literary readings and responded to writing prompts before the second lecture period. These prompts asked students to consider ideas such as the prairie as metaphor, prairie as community, and life lessons from the prairie. Professors guided students through textual explication in class, followed by a group discussion in which they built upon their previous written responses in light of what they had learned in the lecture period. Thus, this assignment created layers of learning: students first encountered the texts personally, where meaning is directly negotiated between the author and the reader. Responding to the instructor's prompts encouraged a different type of learning as students used writing to explore aspects of the texts perhaps unnoticed on their first reading. Their knowledge was further expanded through classroom literary instruction. Finally, open discussion with peers enriched students' understanding of the power and possibilities of nature-based creative literature. The course syllabus contains a complete list of all literary readings (see Appendix A).

Experiential Learning in the Field

During our four-day stay at Konza Prairie, we engaged the students in a series of intensive field exercises designed to build detailed observation skills, practice

creative interpretation, and explore the scientific method. Creative and scientific activities were interwoven throughout the field experience. In this section, however, we separate activities by theme (creative and literary vs. scientific) in the interest of clarity for the reader.

To take maximum advantage of our time in the field, students were expected to complete all course readings before starting the immersive experience. While in the field, we focused on multiple short assignments rather than single, long works. Assignments were designed to encourage high levels of creative engagement, imagination, and open-ended responses, an approach not often taken in the context of science education (Pollack & Korol, 2013). Evidence indicates that limiting the length of writing assignments to short “microthemes” in which students distill ideas without emphasis on grammar or mechanics is an effective practice (Collins, 2004; Leahy, 1994; McMillan, 2014). In the field, our primary goal was to get our students comfortable with the environment and with writing. This, in turn, served to enhance skills needed for post-trip integration of their experience.

Creative and Literary Interpretation

Two writing activities took place on the first day of the trip. The first focused on detailed observations from the Creative/Literary perspective. While this exercise in some ways mimicked the close attention to detail practiced by scientists, it did so through a creative, sensory perspective.

In the first phase, we led students on a short hike then settled them on field trails at intervals which allowed them to work in solitude. Each selected one specimen from the field: forb, leaf, grass, etc. Their assignment was to write detailed observation of this one specimen in their journals, employing every sense: the specimen’s texture(s), sound produced when it is manipulated, appearance, smell, taste (if safe to sample). To encourage sustained, in-depth observation, we required one full page that completely described every aspect of their chosen specimen.

Once this detailed observation was complete, we turned students’ attention from close inspection to a wide, encompassing view. In this second phase, the class hiked 1.3 miles through lowland gallery forest and over limestone ledges to reach a plateau in upland tallgrass prairie. This view overlooked the prairie on three sides, including the Flint Hills and the Kansas River Valley. In the fourth view lay a small highway and farmsteads. Once again, students were asked to write one full page of exactly what they experienced, but this time from a God’s-eye view: colors, vegetation, animal presence, sounds, sensations of sun and wind, and the like. Although the size of the hilltop did not allow complete student separation, students were generally so exhilarated by the unexpected view after a tiring climb that they readily immersed themselves in the experience. Still, we asked them to sit and record observations for at least 20 minutes. This requirement helped ensure that they fully inhabited the time and space and thus captured impressions lost without a slower, contemplative pace.

Throughout the remainder of the four-day trip, we interspersed other Creative and Literary writing activities with scientific ones. In one, we introduced students to haiku, a three-line, unrhymed Japanese poetry form which focuses on images from nature. Haikus emphasize simplicity, directness, and the evocation of a singular moment. Learning and writing haikus requires students to distill a profusion of sensations and information into a clear, disciplined structure. As Pollack and Korol (2013) report, assigning haikus in their science classroom helps students synthesize specific scientific concepts. While our interdisciplinary course focused on ends other than the "scientific fluency" sought in theirs, our experience validates Pollack and Korol's (2013) findings that creative assignments tap distinct cognitive processes compared to other written assignments.

We also added field readings which draw on a Western literary tradition by introducing students to classic odes befitting particular moments in the field; examples include John Keats' "To Autumn" and Percy Shelley's "Ode to the West Wind." Hearing poetry aloud is important for both enjoyment and literary instruction, so we gathered on the open prairie and an instructor (or student volunteer skilled in recitation) performed a reading of these odes to the assembled group. Odes often struck a deep chord with students, with several choosing to write their own in admiration of one specimen or prairie experience as their final creative project. In an open-enrollment course such as this, many students had had little experience with the performance of literature, just as many were new to scientific observations. Consequently, both instruction and modeling were important elements of helping students develop and integrate these skills.

Scientific Interpretation

Science activities focused on how to build hypotheses based on observation and how the scientific method can be used to test hypotheses about the prairie. Examples included completion of a field notebook, a group activity called "20 questions," and a guided scientific tour of Konza Prairie Research Station.

To build observational skills, students kept a field notebook that included a directed natural history exercise. Students located, identified, and provided detailed descriptions of ten species of grasses or forbs (non-woody, flowering plants) as well as ten species of other plants or animals. To award full credit, we required that each notebook entry include date, time, and location of the observation as well as a full description of the organism's habitat. The first field-based writing exercise (described in the previous section) had provided students an example of the level of detail expected. The biology professor gave instructions and supporting materials regarding characteristics for identifying common prairie organisms. For example, in the case of plants, we discussed growth form, leaf shape, position of the leaves on the stem, size, and the shape and structure of the flower. Field guides tailored to the tall grass prairie were provided, and professors were on hand to assist the identification process.

The level of identification varied depending on the organism in question. Bison, for example, could be confidently recorded by their species name, *Bison bison*. Most

insects, on the other hand, were identified to order or family. The objective was not to convert students into skilled taxonomists but to engage them directly with the environment and the process of recording detailed qualitative data. A handful of organisms, such as wild turkey and big blue stem, appeared in all the student notebooks. At the same time, students explored the environment on their own and made unique observations. In addition to narrative descriptions, students often included illustrations in their entries.

To explore the process of creating and testing hypotheses, students completed a "20 questions" exercise, based on a field activity developed by the Organization for Tropical Studies for graduate and undergraduate field courses (Organization for Tropical Studies, unpublished). In the Konza Prairie adaptation, each student generated 20 questions about the prairie based on course readings, written exercises, and natural history observations. Students then worked in small groups to select one question around which they developed a testable hypothesis. Under the guidance of the biology professor, each group then designed an appropriate experiment to test their hypothesis, taking into account independent and dependent variables, sample size, and other important considerations. Proposed experimental designs were then shared with the entire class in an informal seminar.

To observe real-world applications of the scientific method, we completed a half-day scientific tour of Konza Prairie Research Station, including the opportunity to see bison. Every semester, one of the station scientists generously contributed her time for this activity, explaining to students how large-scale, landscape-level questions are being addressed at the LTER site. Students traversed Konza watersheds to see how they are divided into experimental parcels to examine the impacts of variables such as grazing, fire, and drought on biodiversity. They also learned about practical aspects of prairie management, such as the logistics of controlled burning and maintaining a viable population of grazing bison.

Post-Trip Integration

Following the Konza Prairie field experience, we engaged with the students in processing the experience through three class meetings and additional follow-up assignments. These assignments included the Final Creative Project and Comprehensive Essay. Approximately one week after the field trip, students also completed an exam that covered both scientific and literary content of the course.

Final Creative Project

Students completed a final written project based on their experiences during the field portion of the course. They could write in any genre: natural history, creative nonfiction, poetry, or any type of fiction. Students wrote short stories, screenplays, and created illustrated books for first graders. They crafted odes to natural elements and detailed travelogues. While the final project was creative in nature, students had to incorporate a scientific foundation as part of their work. In other words, scientific knowledge of the prairie had to be accurately reflected in the creative product. A sample rubric is provided in Appendix B.

Getting good final projects required solid groundwork. The process we found successful began with meeting individually with each student while still at Konza Prairie. On the afternoon of the third day, when most of their field work had been completed, each student signed up for a 15-minute session with both professors to discuss their ideas for the final project.

A prospectus was due three weeks after returning from the field trip. Both professors reviewed these and either approved as-is or recommended changes we believed would help students be more successful. First complete drafts were submitted two weeks later. Again, both professors reviewed these drafts and offered written critiques on content, form, and writing mechanics.

Students submitted their final revised pieces four weeks later. The class met one last time for students to orally present their creative projects. While some students initially seemed reticent to present, our experience was that they became more confident as they listened to their peers and relaxed in the supportive atmosphere.

Comprehensive Essay

After submitting their final creative project, students composed a 500–750-word essay that addressed the main theme of the course. Building on their course experience, they discussed how both scientific and creative modes of inquiry contribute to our understanding of the prairie. They also articulated the advantages and challenges of integrating these modes of inquiry, describing how creative inquiry enhances scientific understanding and how scientific knowledge informs creative inquiry. A sample rubric is provided in Appendix C.

Findings

From the first semester we ran this course, qualitative and quantitative measures of student success have met and exceeded our expectations. In this section, we discuss how students achieved learning objectives as illustrated by the final creative project and comprehensive essay. We also highlight more general responses to the experience as recorded in student evaluations.

Final Creative Project

We have been impressed by the number and variety of ways our students applied their prairie experience to the final creative project. They utilized a range of written formats, including natural history essays, short stories of all genres, poems, memoirs, children's stories, and screenplays. One student well advanced in writing skills even developed their own genre of expression uniquely suited to communicating their understanding of the Flint Hills. Here we describe a sampling of projects generated by students.

Students from urban settings often confronted fears about nature. In many cases, these students used the creative project to illustrate their personal journey in a metaphorical fashion. Their stories often featured characters that went from being fearful of nature to experiencing comfort and joy in the natural world. One student

who wrote about this theme developed a children's story with a special target audience: their niece. After going from fear of nature to a deep appreciation of the prairie, this student wanted to help a beloved family member make the same transition through storytelling.

Several biology majors enrolled in ETWL. Often coming from a cell or molecular biology background, they discovered a passion for ecology as a result of their prairie experience. Our science students have produced diverse creative works for their final creative projects, including poetry, humorous pieces, and fantasy short stories. Inspired by ETWL, several have gone on to complete capstone research projects on some aspect of prairie ecology. For example, one student wrote a poem in the form of an ode to the monarch butterfly. Because of her own history, she found a companion spirit in this beautiful species that undertakes a multi-generational migration across North America. In the semesters that followed, this student decided to dig deeper into the science of monarch migration. For their capstone project in the Biology major, this student conducted an in-depth literature review on monarchs in the Americas, comparing their migratory habits to painted lady butterflies in Europe and Africa.

No matter our students' backgrounds, they have found numerous opportunities to relate on a personal level to the tall grass prairie. Even our international students, who face an additional challenge with English as a second language, have benefitted from this course. For example, we had a student from Central America who was anxious at the beginning of the semester because of their uncertainty with the language as well as an overall sense of being "out of place." We met with this student individually to encourage them to stay, emphasizing the unique and valuable perspective the student could bring to the group, given their prior experience with the Neotropics. For the student's final creative project, they crafted a skillfully written poem that compared the starry nights of the prairie with the starry nights of the tropical beaches in their home country.

Comprehensive Essay

As described earlier, the comprehensive essay asked students to articulate their understanding of the primary theme of the course: the benefits and challenges of integrating scientific and creative/literary modes of inquiry. We graded the essay on a 10-point scale. All participants earned at least a 7 (C or passing) grade with an average score of 8.3 (B). Overall, we were pleased with the thoughtful and engaged responses of our students. Representative excerpts are provided in Figure 1.

Course Evaluations

A total of 32 students have participated in ETWL across three semesters (2014, 2016, and 2018), of which 29 responded to course evaluations (10 in 2014, 9 in 2016, and 10 in 2018, with one student not responding each semester). On student evaluations, the vast majority have ranked course quality and teaching as "excellent" or "above average." On a scale of 1 to 5 (1=excellent, 5=poor) the average student ranking for the course has remained at or near 1.2 overall. Student comments on evaluations reflected what we heard informally in the field

and classroom. They consistently identified the course as not only fun but “life changing.” They expressed appreciation for the connection they developed with the prairie as well as the opportunity for simultaneous intellectual growth in more than one academic field.

Figure 1

Selected Excerpts from Three Final Comprehensive Essays

“The beauty of both [scientific and creative inquiry] is that they compliment [sic] each other well. For example, when describing an organism, it is natural for a proper description to include details of shape and color but when that description is written with the intent of holding a reader’s attention . . . writing and science can genuinely blend and flourish . . . [A]pproaching an ecosystem with both modes allows one to genuinely convey the setting, appearance, and feel of the world in an appealing manner while simultaneously understanding . . . why its existence came to be and how it is still functioning.”

“. . . [creative] writing tells a story that reaches the reader in a way that scientific writing often can’t. The facts that are being stated become interesting, and the reader cares about them. Instead of skimming over calculations and statements, the reader creates a personal experience . . . This new world of writing creates a personal connection between the author and the reader.”

“Reading the scientific literature can be very boring . . . Given the current situations with climate change and people not vaccinating their children, science needs a new public relations plan . . . People do however understand story telling . . . Science can use this personal connection a reader can have to a literary work to tell the truths about the world . . . using creative means to get people interested in nature can help make a domino effect of people wanting change in the world.”

Note: In this assignment, students described how creative inquiry enhances scientific understanding and how scientific knowledge informs creative inquiry.

Discussion

Over the three semesters of ETWL, students from diverse disciplinary backgrounds have consistently achieved course objectives. By engaging in detailed natural history observations, generating original hypotheses, designing experiments, and observing how science is applied to real-world situations, ETWL students came away with a deeper understanding of how scientific knowledge is generated. Students also engaged in critical exploration of creative literature and writing, and

they successfully used scientific knowledge of prairie ecosystems to inspire creative expression as evidenced by short field assignments and the final creative project. In the final comprehensive essay, students articulated how creativity contributes to the scientific process and how science informs creative inquiry. Through the comprehensive essay, students demonstrated an understanding of the importance of both scientific and creative paths of exploration when interacting with our natural environment. Throughout the course, students developed and strengthened their writing skills while exploring the central role of metaphor in understanding our world and ourselves. The results we observed when integrating literary and scientific modes of inquiry are supported by other published studies of interdisciplinary and transdisciplinary approaches to science education (Brown, 2015; DeHaan, 2011; Mueller et al., 2014; Pollack & Korol, 2013; Scheffer et al., 2015; You, 2017).

We also found that many students underwent a transformative experience even though the immersive portion of the course was short and close to home. This was evidenced by recurrent themes in class discussion and creative projects, such as the challenge of overcoming fear of natural spaces. Students succeeded in converting trepidation into excitement through direct engagement with, and a greater understanding of, the natural environment. Every student finished the course producing creative work that reflected deep respect for, and foundational knowledge of, the tall grass prairie ecosystem. That brief immersive experiences close to home can be transformative has also been reported by other authors, for example, in the context of place-based science education (Gray & Thomson, 2016; Jacobson et al., 2016; Mueller et al., 2014).

In traditional academics, there is sometimes a desire to broaden students' experiences in giant leaps. We may believe we are showing students a larger world only if we take them to a distant part of the country or to another country entirely. As instructors, we started ETWL with this preconception. For example, we had considered implementing the course in a tropical environment such as the forests of Costa Rica. However, because many of our students are non-traditional or come from financially stressed situations, choosing a nearby site made the course more accessible in important ways. Student fees for Konza Prairie totaled one-tenth the budget necessary for an international course. Students with family or work obligations who could not be away for extended international travel were able make arrangements for a short field experience in the Flint Hills.

An unforeseen benefit of the immersive field component was the sense of community that emerged among students. This bonding was engendered in part by the field setup, where students shared the same cabin, coordinated cooking and cleaning, shared field guides, and helped with assigned tasks, such as identifications. This communal experience created personal bonds that encouraged them to learn from and support each other. Bonding was also facilitated through integrative activities. For example, every evening all course members took part in a story circle where we shared something from our journal or the day's experience. Often these included a moment of surprise or an appreciation of an expanding sense of self as members of the natural community. In their post-trip assignments,

students recognized this process and drew parallels between their experience and what they observed in the tall grass prairie community (Figure 2).

Figure 2

Experiences of Connection and Community

“When I observed the prairie, I did not see just land, I saw a community of all types of life that had a common goal of surviving. . .”

“. . . the writing allowed me to see and feel the connections that my classmates made to the prairie. I could see how their views had changed as they read their pieces. Even if I was not there when they had their experience, I could feel what they went through.”

“We became more of a community who now cared and learned about something bigger than us. . .”

Note: These observations represent excerpts from different integrative assignments and course evaluations following the immersive field experience.

Implications

Complex global challenges demand novel approaches to enhancing scientific literacy. This process cannot be divorced from engaging each other and the environment as part of the same community. Based on our experience, the semester-long undergraduate course Ecology Through the Writer’s Lens is one model by which scientific understanding and creative expression can be integrated to better connect students with each other and the natural world. We observed that the course benefited both science and non-science majors in important, complementary ways. Non-science majors developed a greater understanding of the power of science as well as a deeper appreciation of the importance of verified facts in the pursuit of knowledge. Science majors learned how creative approaches to observation can open new pathways for exploration, adding a different kind of scaffolding on which to build scientific inquiry. Particular strengths of this course included its accessibility to a broad range of students, many of whom had not previously traveled far from home.

While this paper has detailed our experience merging Ecology and Writing, many disciplines may be fruitfully combined. As noted earlier, our institution has a long history of offering interdisciplinary courses. For example, faculty from Visual Design and Rhetorical Studies teach The “Art” of War, which explores differences between rhetoric and propaganda. Like ETWL, The “Art” of War includes an immersive travel component in the form of a four-day trip to Washington, D.C. Likewise, faculty from Biology and History teach the course Plagues. Conducted entirely on campus, Plagues considers the transnational causes and effects of epidemics, including their

origin, techniques of control, and contemporary ethical debates concerning the nature of disease and treatment of patients. Through the combined experience of Avila faculty, three factors have been revealed as essential for interdisciplinary course success, regardless of the disciplines being combined: faculty collegiality, effective communication between co-instructors, and equal treatment of the disciplines represented in each course.

As a final note, we want to mention the special challenge of implementing a field-based course during COVID-19. Because the pandemic precluded our class from sharing living quarters in the field, during Fall 2020 we brought ETWL even closer to home. Instead of an extended field trip to the Flint Hills, we conducted our field exercises in a series of day trips to prairie, woodland, and wetland sites close to campus. Due to the pandemic surge in November, students shared their final creative pieces during a virtual meeting. This was the first semester we ran the course under this protocol. For this reason, it is difficult to draw conclusions as any differences between our Fall 2020 experience and previous semesters may be due to idiosyncrasies of this group as well as the larger social stresses affecting campus and academic life. Nonetheless, we found the major course objectives were successfully met for most students under this new format. At the same time, communal aspects, such as the group bonding that came with the visit to Konza Prairie, were missed. While our preference continues to be for a multi-day field immersion experience as part of the course, our experience this semester indicated the basic practices developed for ETWL can be adapted under different circumstances and needs. We also recognize, in hindsight, the benefits we received as instructors by adapting this course so that it could be offered despite COVID-19. Even in a scaled-down field environment, students responded to their scientific and literary discoveries with enthusiasm. At a time when the regular rhythms of academic life had been totally disrupted, the choice not to cancel the course but to find a creative way to carry it forward helped carry us forward as well.

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Author Contributions

Both authors contributed equally to the design, implementation, and assessment of Ecology Through the Writer's Lens. We also contributed equally to the submitted manuscript.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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Appendix A

Sample Course Syllabus

IS 365 Ecology through the Writer's Lens

Prerequisites

Completion of Core Foundations

Textbooks

Savage, Candace. 2011. *Prairie: A Natural History*. Greystone Books, Vancouver, Canada.

Literary selections distributed in class and on Canvas. (See "Bibliography of Literary Readings" at the end of the syllabus.)

Course Description

Students will integrate literary and scientific modes of inquiry while engaging in an in-depth study of the natural world. Each semester will focus on a particular ecosystem such as tropical forest, temperate grasslands, temperate rainforest or montane ecosystem. The course will include a multi-day field trip, providing a first-hand experience of the ecosystem of interest. This ecosystem will serve as both a laboratory and a writer's workshop where students will generate hypotheses and create new meanings.

Before the trip, students will study the particular ecosystem and read representative works in nature writing, including scientific writing and creative writing. During the trip, students will write journals and narratives, do scene painting with words, and conduct detailed natural history observations geared toward generating hypotheses about species interactions and ecosystem dynamics. For their final writing project, students may focus on natural history, creative nonfiction, or fantasy. Students will share their work with the class at the final course meeting.

Please note that IS 365 is blended course that includes coursework online, in the classroom, and in the field. Students are responsible for keeping track of assignments, schedule changes, and other announcements on Canvas.

Course Learning Objectives

- Acquire a foundation of knowledge about the focal ecosystem.
- Develop and strengthen writing skills through a variety of writing experiences.
- Explore the central role that metaphor plays in understanding our world and ourselves.

- Generate scientific hypothesis on the basis of detailed quantitative and qualitative observations of the natural world.
- Use scientific knowledge to inform other types of writing: nature writing, creative nonfiction, poetry, and fiction.

Evaluation

10%	Participation
10%	Field Exercises
15%	Classroom Exercises, Homework, Quizzes
20%	Field Journal
15%	Exam
10%	Comprehensive Essay
20%	Final Project

Participation

This course is based on the principle of building a strong academic and interdisciplinary dialogue among the participants. To have a positive learning experience, active participation—coming prepared to class, engaging in discussions, listening to the perspectives of other students, critically examining the readings, and so forth—is essential. Attendance is mandatory.

Field exercises

During field exercises, students will record observations, generate questions and hypotheses, and discuss experimental design. Field exercises will, for the most part, be completed during the field trip.

Classroom exercises, homework, and quizzes

This course includes classroom exercises where students will develop and clarify concepts relevant to prairie ecology. Homework may be assigned, and periodic quizzes given over readings and lecture material.

Exam

One exam will be administered mid-semester, shortly after the field trip. The exam will be of mixed format, including multiple choice and short answer questions.

Writing Journal/Field Notebook

Students will keep a field notebook in which they will record daily natural history as well as personal and scientific observations. Each entry should be dated, and notes must be as detailed as possible. Notes may include a variety of observations, such as descriptions of plants and animals, quantitative or qualitative data gathered during field exercises, sketches, bird lists, poems, and so forth.

In addition, students will write a reflective piece at the end of each day. These entries should record thoughts about what you have experienced, such as your emotional/intellectual/spiritual response to something you saw, learned, or took part in. Additional detail on expectations for writing journal/field notebooks will be provided by your instructors.

Final Project

Students will submit a final written project based on their experiences during the field portion of the course. Written projects may be natural history writing, creative nonfiction, or any genre of fiction. Students will work closely with instructors and other students, including the submission of drafts, to complete their projects. The final written project must be an original work completed by each individual student. Projects that do not meet this requirement will receive an "F." Please see Avila's policy on plagiarism.

Comprehensive Essay

Toward the end of the semester, students will submit an essay discussing the theme of the course: the integration of scientific and creative modes of inquiry. Detailed expectations regarding this comprehensive essay will be provided by instructors.

Tentative Course Schedule

The instructors reserve the right to make adjustments during the semester if deemed necessary. The schedule of classroom meetings does not always reflect on-line work and assignments. This is a blended course, so you must check canvas for updates on course work and assignments. Students must complete the assignments on the due dates given.

Date	Topic	Readings
Aug 28	Course Overview, Logistics	
Sep 4	Prairie Ecosystems	Savage Chapters 1-4
Sep 18	Natural History and Creative Writing	Assigned Canvas readings
Sep 27- Sep 30	Field Trip to Konza Prairie (Detailed daily schedule is below.)	Savage Chapters 5-9 Assigned Canvas readings
Oct 9	No class meeting, but there will be a Canvas Quiz	
Oct 23	Exam Final Project Prospectus DUE	
Nov 6	Final Project DUE for review and revision Self-Assessment DUE	
Nov 20	Final Presentations Revised Project DUE	
Dec 4	Comprehensive Essay Due	

Konza Prairie Schedule

Note: we will not have access to the internet at Konza Prairie, so Canvas readings must be completed ahead of time.

Thursday, September 27

8:00am Meet on campus to depart.
11:00am Arrival at Konza Prairie Biological Station. Settling in.
12:00pm Lunch
1:00pm Orientation and walk through the Facilities.
2:00pm Visit to nature trail. Plant identification; observation writing exercises.
Remember to take your field notebooks, field guides, water, sunscreen, and snacks.
5:00pm Return to cabins.
6:30pm Dinner
After dinner: Group reflection, reading, journaling

Friday, September 28

9:00am Field Exercise: 20 questions, hypothesis building and experimental design.
12:00pm Lunch
1:00 pm Writing exercises in the field (haikus and odes); work on field journals.
6:30pm Dinner
7:30pm Night Walk
After walk: Group reflection, reading, journaling

Saturday, September 29

9:00am Tour of reserve and visit to buffalo area with Dr. Eva Horne. Conservation, management, and research at Konza Prairie.
12:00pm Lunch
1:00pm Project planning/reflection/journaling. Individual meetings with course instructors.
6:30pm Dinner
7:30pm Discussion: Prairie Conservation. Reading, journaling.

Sunday, September 30

7:30am Cleanup cabins and pack. Remember that if you use Konza Prairie linens, you must wash them before departing.
9:00am Departure
11:30am Arrival at home campus

Bibliography of Literary Readings

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Appendix B

Grading Rubric for Final Creative Project

Criteria	Point Range
Engaging: the piece is interesting, capturing and holding attention throughout. Language level is appropriate for the target audience. Observes conventions for the specific genre (poetry, short story, natural history essay, etc.).	5-0
Scientific accuracy: reflects lived experience in the field. Creative work shows clear evidence of grounding in scientific knowledge. With the exception of creative license that serves the objectives of the work (e.g., allowing animals to talk in children's books), all scientific information is correct.	5-0
Language command: reflects mastery of Standard American English.	3-0
Process: reflects active engagement with professors' written feedback and comments.	2-0

Appendix C

Grading Rubric for Comprehensive Essay

Criteria	Point Range
Modes of inquiry: articulates a clear understanding of both scientific and creative modes of inquiry, including the strengths and limitations of each.	3-0
Integration: thoughtfully discusses the value of integrating scientific and creative modes of inquiry in understanding a natural system such as the prairie.	3-0
Cites specific examples from readings and course activities that appropriately illustrate essay contentions.	2-0
Language command: reflects mastery of Standard American English.	1-0
Adheres to page and format instructions.	1-0