



Capturing the Transdisciplinary Dragon: Creating a Crossover Natural History-Art Exhibit

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Although transdisciplinarity has been in practice for decades, its use as a methodology in higher education is limited. In addition, the need to connect academe to the community outside its walls has never been more pronounced. Working within the gaps created between disciplinary boundaries gives researchers an opportunity to create new ways of understanding the common, yet complex problems of the world. In this article we explain how a group of student researchers, scholars, and other community members came together to create a transdisciplinary exhibit that explains how plant fossils and dragon folklore are connected worldwide. We provide evidence of how the creation and implementation of the exhibit facilitated learning across wide cross-sections of stakeholders and how the project continues to develop new avenues of inquiry.

Keywords: Natural history, art, dragons, plant fossils, fossil, folklore, exhibit, STEM, STEAM, transdisciplinary

1 Introduction

The ability to understand how our world functions has never been more important, yet, science associations [1-2], businesses [3], and even governments [4-5] have noticed that students lack the understanding of basic science and the skills necessary to properly do science [6]. The conceptual understanding of science, including science literacy and the innovations it can bring, is low [7-8] therefore, science must be made accessible to increase scientific literacy across a population. As the world is faced with ever more complicated problems like environmental crisis, medical needs for an ever aging community, and disease control, we must have a community who is comfortable working together. Learning opportunities that are embedded in real inquiry and spread among multiple stakeholders are the best way to solve this knowledge deficit [9]. These opportunities encourage buy-in and skill-building that reach far beyond the task at hand, allowing students, scholars, and community members to realize authentic knowledge

gains as well as a sense of fellowship.

Transdisciplinarity, a term coined in the 1970s [10-11], entails working beyond discipline-specific methodologies, and constructing new conceptual knowledge without denigrating “the methodology of each discipline” [12]. Another phrase of note from the same time period, “wicked problems,” was generated to describe issues not able to be solved by the traditional research paradigms [13]. Today the research literature has become populated with work that incorporates these ideas. Brown, Harris, and Russel [14], McGregor and Volckman [15], and Scholz [16], find that a transdisciplinary framework is the best way to engage multidimensional challenges as it allows the freedom to approach solutions without disciplinary constraints. Transdisciplinary concepts are applicable not only to research, but to pedagogy in general [17], particularly collaborative work [18-19].

STEM/STEAM pedagogies are becoming the norm as society recognizes that students must not only be science-literate, but also grasp the problem-solving and ethical thinking skills needed for progress in a rapidly changing world [20-22]. STEAM research brings together the processes of the arts and the scientific method, combining their strengths to observe, create, collaborate, and build a synergistic learning environment. These collaborations do not come without tension, but the dynamic friction produces sparks that often ignite new ideas and illuminate new inquiry pathways [23-24].

An example of this kind of STEAM-based, transdisciplinary project is the inquiry into how Carboniferous plant fossils influenced dragon folklore around the world [25]. When one thinks of dragons, the association of fire is a natural extension. After all, many dragons breathe fire, scorching their adversaries and everything around them; fire is part of the dragon’s power. It is this “firepower” that might logically become associated with the spark of creativity and action. A generative, rather than a consuming fire can provide necessary energy to a creative project. The more fuel added by the collaborative efforts of many, the larger and brighter the fire burns. Our research team, the Dragon Research Collaborative (DRC) generated a cohesive narrative through the creation of a museum exhibit that connected many of the team’s disparate, smaller inquiries. This unique showcase provided the opportunity to construct a multifaceted story, answering the main research question while continuing to light

additional fires of inquiry.

2 Materials and Methods

Dragon Research Collaborative – The DRC is a group of students, faculty, staff, and community partners working together to answer the overarching question “do Carboniferous plant fossils influence dragon folklore around the world?” [26].

Pilot Exhibit - After a year and a half of independent student projects and small scholarly studies, students were challenged to find ways to showcase their own work and to bring all their ideas together to form a single narrative. Weekly small groups, pre-determined by the researchers, collaborated on these tasks. The small groups were accountable to the larger group, regularly reporting to one another their accomplishments. Within one semester, a pilot exhibit, “Here Be Dragons,” (Figure 1) was created and showcased at a college event.

Meeting Structure and Supergroup Formation – Due to the structure of the DRC’s multi-disciplined projects, the lead primary investigators organized a single weekly meeting where all student researchers and occasionally other scholars attended. During these meetings, students discussed their project’s progress, then everyone was put into smaller groups based on their interests, strengths, and individual project focus. These supergroups [27] began to act as small think tanks within the larger one. Supergroups met each week for a complete academic year, each responsible for making connections among their individual projects to create a unifying visual display (Figure 2). One supergroup contained students working on individual botanical questions surrounding the centralized fossil-folklore inquiry, building an ethnobotanical display about scientific names containing draco, and how medicines are derived from plants. Another supergroup collected examples of dragon folklore to show how fossils from those regions match descriptions provided in text (a complete list appears in Figure 3).

Some individual projects did not connect as clearly to another and those individuals were asked to produce a single exhibit product on their topic (e.g. dragonfly mouthparts); these same students also participated within a supergroup as part of the brain-trust. The DRC works under the idea that everyone brings an integral perspective and strength to a

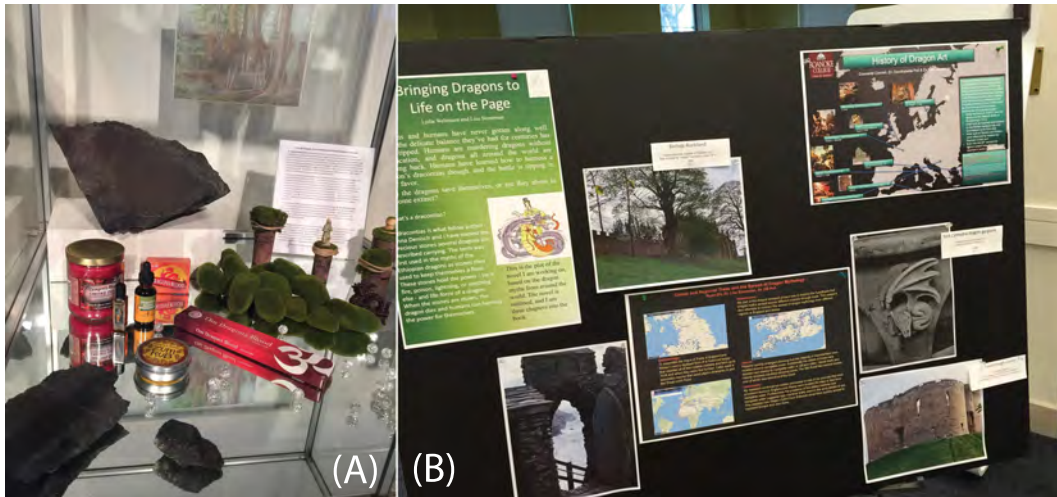


Figure 1: (A) Pilot exhibit artifacts of a single project on ethnobotanical plant parts sold or used as medicine. (B) A cluster of posters that show individual projects connecting to larger themes.



Figure 2: Supergroups meeting to discuss how their projects connect.

challenge and we did not want to isolate talent by allowing a single student to work completely outside a supergroup.

After supergroups met the weekly goals set by the primary investigators, the supergroups presented their ideas to the rest of the team. At these times, team members added to, questioned, or celebrated what was presented. Creative thinking was highly encouraged and acknowledged; no ideas were thrown away. This transdisciplinary workshopping had the express goal of bringing about new questions, new research paths, and new knowledge associations.

Role of the Museum Experts – In order to ensure that the group held to the best practices of mu-

seum studies and exhibit design, the DRC research team met with an art gallery director and members of the state natural history museum several times throughout the development of the exhibit. Specific attention was given to the development and relay of information placed on panels throughout the exhibit. In addition, the importance of the visitor's experience, essential for a successful exhibit, was reinforced by the experts who extensively discussed walking/traffic pattern flow and artifact placement. In order to receive maximum value from this guidance, the DRC provided the experts with a strong understanding of the curated artifacts and the big picture topics developed for exhibition. These discussions occurred during the normal DRC meeting

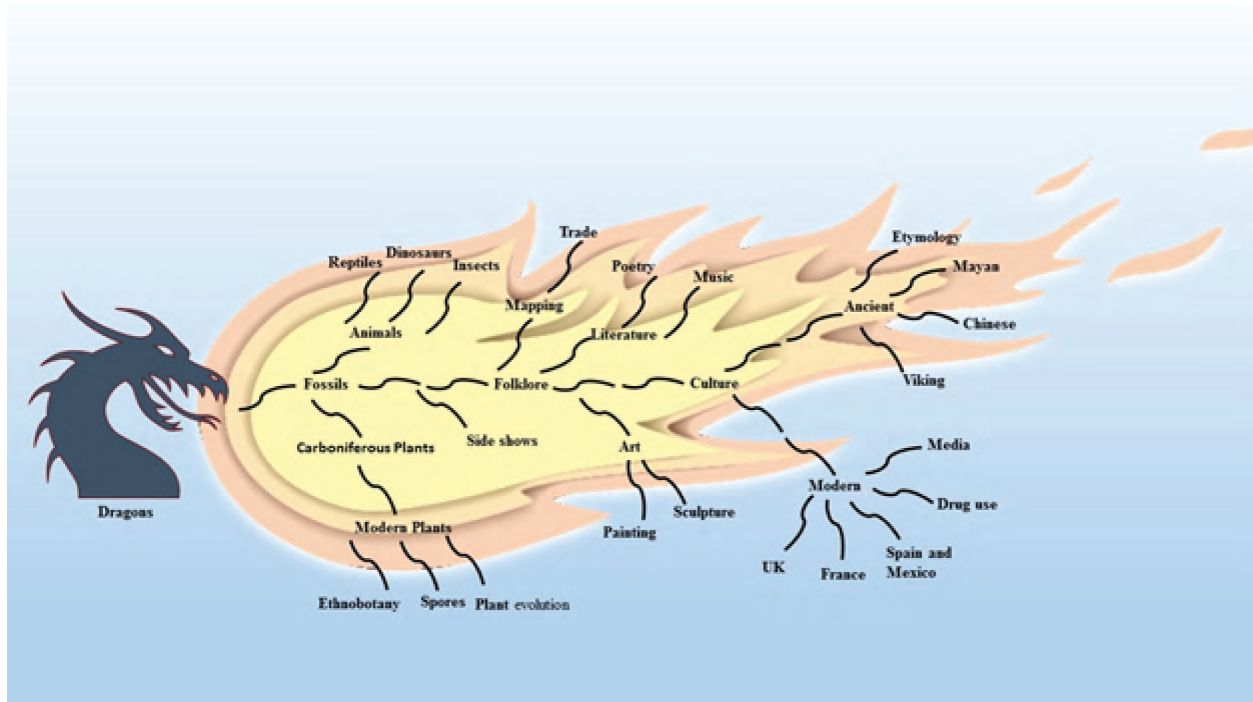


Figure 3: Progression of DRC projects to *Here Be Dragons* artifacts.



Figure 4: Examples of artwork created for exhibit, *Here Be Dragons*.

times for a total of three meetings. Both the art director and the museum staff members initiated and continued open dialogues throughout the process. Emails, phone calls, and small group meetings resulted.

In addition to the science and folklore artifacts developed, several artists worked as a part of the DRC to create original products that complemented the idea of the plant fossil-folklore hypothesis. Original music was scored, several paintings and community art projects were completed (e.g. dragons with *Lepidodendron* inspired scales, sideshow posters, Tarasque glicée; see Figure 4 for additional examples), a steampunk dragon sculpture was erected, and a poet wrote several works for display (Figure 5).

Designing Furniture and Props to Create Exhibit Cohesion – To properly showcase the individual smaller exhibits, but still retain a unified feel to the whole, a local furniture maker was contracted to create foundation pieces. Through discussion, it was determined that a steampunk furniture style would be used as it would artistically highlight the natural history without conflicting with the other creations. Wood, metal, and black fixtures were consistent across all furniture pieces.

To add dramatic flair, a circus/sideshow tent, ten feet in diameter, was sewn and suspended in front

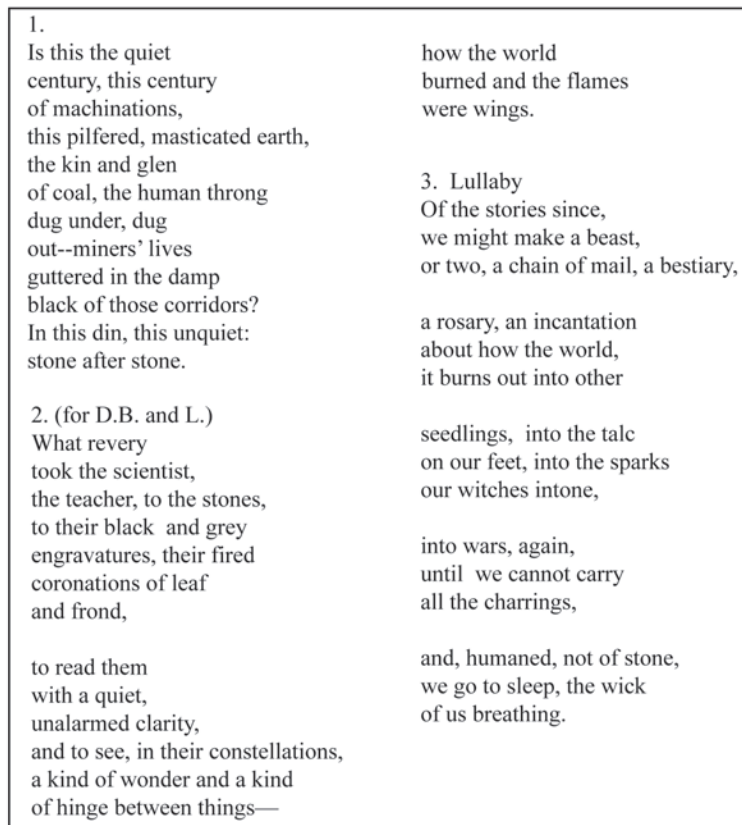


Figure 5: *Fossil*, Melanie Almeder, American Poet, 2016, who participates in the DRC.

of the entrance, funneling visitors through a single experience at the start of the show. A large *Lepidodendron* fossil cast was set in the middle of this display, intentionally connecting the steampunk design and the sideshow history of the plant fossil-folklore hypothesis.

Development of Pedagogical Supplements – Connections among the fossil-folklore concepts may not be obvious to children, so to ensure more K-6 interactions within the exhibit, we developed tools that related to, but expanded on the Virginia Standards of Learning in the elementary and middle grades. A children's corner with a reading nook and interactive art and story creation opportunities was created to focus this younger audience. These activities helped facilitate the visualization of the dragon by allowing children to interact with the literature, geology, and paleontology-directed lessons. In addition, an activity book was developed, featuring original characters and authentic plant fossil drawings [28]. The book was translated into Spanish, French, Twi, and Chinese to reach a broader audience. Stuffed toy

dragons were suspended from the ceiling to conjure the feeling of a giant mobile overhead. Even though this section was developed with children in mind, adults were also encouraged to participate in the activities.

Development of a Festival from the Exhibit – A festival is structurally different from an exhibit. The energy necessary for a festival has to be constant in order to foster a level of entertainment that keeps people engaged. To accomplish this goal, the crossover exhibit was broken into smaller units throughout the partnering festival location. Then, supplementary components were added to garner the interest of varying age groups, with experiential activities being the primary focus for the researchers. The DRC decided to partner with community history reenactors and festival performers (i.e. fire breathers) while adding typically child-focused opportunities such as face painting, selfie photo stations, and a variety of crafts.



Figure 6: Opening of *Here Be Dragons* at Wilson Hughes Gallery in Roanoke, Virginia, USA, 2016.

3 Results

Research and Exhibit Reach

The first iteration of the museum exhibit was small and displayed in approximately 250 square feet of ill-fitting space at a college showcase event. Students made 11x17 inch posters for each of their individual projects. They then combined these ideas into larger posters that represented their collective research (Figure 1). In addition, students began experimenting with the artifacts portions of the larger exhibit. For example, students created a laptop-displayed video game; recorded different language examples of the word “dragon,” playable on an iPad; featured examples of dragon art throughout history; and designed a basic display about dragon medicines using old bottles, “dragon” incense and oils. Together they worked out how to layout the information to tell the collective stories.

Overall, this initial exhibit design was rudimentary, but the students were excited by the attention at the showcase from faculty, students, and staff; the unique quality of their transdisciplinary approach created a sense of excitement in the audience and among the researchers. This attention provided the inspiration, energy, and necessary group focus for the next step in exhibit design. Students also discovered additional collaborators in faculty and staff who showed interest in the project [29].

The second iteration resulted in the true cross-over natural history and art museum exhibit. There is no reason to design an exhibit if it does not have a place to be displayed; therefore, the group reached out to a local art gallery who provided the exhibit space for

a month-long show. Approximately 1000 square feet of space was transformed into a steampunk meets dragon natural history experience. These larger and more detailed displays required much more time in development of informational panels in order to ensure a unified tone throughout the exhibit. The larger space allowed visitors to walk through a sideshow tent to be introduced to the unifying question of the project: Do Carboniferous fossil plants influence dragon folklore around the world? *Lepidodendron* fossil panels discussed links between the common giant serpent (not dragon) Victorian hoax and the fossil. As visitors exited the tent, a dragon kaleidoscope was revealed. The giant serpent became more defined as a dragon. Flags from around the world, original music, poetry, paintings, sculpture, literature, maps, biology, and geology were woven together in an organic pattern of culture and science. Visitors could walk in the direction of their choice and gain a similar experience about dragon folklore and ties to the plants of the Carboniferous era (Figure 6).

The exhibit was advertised on social media, in the local newspaper, and on the area’s National Public Radio station. Opening night was planned as part of another art community event with attendance far exceeding expectations. Over 200 people from the community attended the opening; other gallery owners informed the team that the marketing behind this show brought more people out than they were used to seeing. The exhibit was available for a month and maintained steady visitation. After closing, portions of the exhibit traveled to other

galleries, festivals, and displays upon request (i.e. Sedalia Celtic Festival).

The success of this cross-over exhibit allowed the DRC to begin discussions with the Virginia Museum of Natural History (VMNH) in Martinsville, Virginia, on collaborating to turn the exhibit into a full-sized festival. Exhibit artifacts retained their scholarly content, but educational entertainment became the focus for the shift into festival mode. It should be noted that a smaller version of the festival was held approximately six months earlier at Roanoke College (Salem, Virginia) allowing for testing of visitor reaction to these additions. Partnering with reenactors, historical education groups, fire performers, and even animal rescue groups ('dragon' petting zoo) created a Renaissance Faire environment that was crucial in fostering a sense of fun to accompany the educational content. The college event brought in several hundred new visitors and with continued tinkering to the lineup of events, the first year's VMNH festival experience reached approximately 1000 visitors (Figure 7).

For the last two years, both the college and VMNH Dragon Festivals have continued to grow in visitor experience numbers and in entertainers, vendors, and community partners. Additional scholarly content continues to be developed and partnering scholars are invited to give lectures or develop their own artifacts. Each iteration requires that a continual project history be recorded and replicated while also allowing for project evolution, so that unique features may be added to improve and widen the experience. This constant dragon rebirth gives more students, scholars, and community partners the chance to add their input to the research questions and answers. Over a five-year period, 60 student researchers have been trained, 15 scholars have been involved, six community partners have participated, and at least 3000 people have explored the work of the DRC.

Pedagogical Gains

Creating a museum exhibit to tell the story of several diverse, yet connected projects, is an excellent example of collaborative, transdisciplinary learning. Tasking the student research team with developing this crossover natural history-art exhibit revealed hidden pedagogical needs. Students had found and worked successfully with their small project mentor experts, but now they needed to take that content and synthesize it with components of museum studies and design aesthetics. The authentic need for the

new knowledge pushed them to learn quickly and to make application. The speed and accuracy of the knowledge acquisition exceeded what is generally seen in the traditional classroom.

Student buy-in remains high for this project. Even during times when tasks posed such daunting challenges that morale was negatively impacted, sometimes causing lags in production, students persevered through the difficulties. They expressed the intrinsic need to properly showcase the whole project and this intense ownership kept motivation high. In addition to the intense learning expectations, the project was plagued by naysayers who questioned the student and scholar researchers constantly about the validity of the dragon project. Rather than discouraging progress, the perceived disdain drove the students to work harder to pull the exhibit together as clearly as possible. Faculty and other mentors reported that students who typically performed at academic levels below average, became focused and determined in this more self-directed research world, behavior that was not witnessed in traditional classroom settings.

As independent projects were critical to the overall exhibit, students needed solid time management skills. The need to weave the threads of the individual work to produce a cohesive exhibit required everyone to work well in groups. The undergraduate students reported that the weekly research meetings helped ensure that they completed expected tasks, as their primary investigators and peers held them accountable. Students also talked about the importance of actively listening to one another in order to complete tasks in a fashion that authentically represented what the group feedback envisioned.

Communication came in many forms beyond basic listening and writing. Since this project is inherently transdisciplinary, everyone worked with someone outside of their immediate major or scholarly interest at least once. In order to be effective in communicating needs and wants, everyone learned to read, speak, and write in the "language" of the different disciplines. Eventually students stopped talking about the "science" projects or the "humanities" pieces and became comfortable discussing project components from a synthesized perspective. To get to this synthesis functionality, everyone had to take on the roles of mentor as well as mentee in differing scenarios. Several good things came of working beyond the boundaries of discipline. Students reported that teaching one another about their portions of



Figure 7: Scenes from Dragon Festivals.

the project deepened their understanding of content and allowed them to practice refining their arguments. The constant sharing and back-and-forth critical feedback cycle eventually became seamless and every student could discuss the work of every other.

Students also learned that communicating their

scholarly work to the general public required a different skill set. Language needed to be geared to a general public level while still conveying the necessary ideas. Students also had to learn how to make all projects visual; this was a lesson that was harder to incorporate into some projects. The challenges in “seeing” project components were met through

the groups' collaborative interactions. Students reported that this visual representation, though one of the hardest parts of their research experience, was made possible by the critical feedback cycles of regular meetings and listening to the reactions of other students.

Throughout, students reported gaining skills that transferred to other coursework and, they hoped, beyond their undergraduate education. Several students reported noticing that research questions had stronger answers when addressed by multiple disciplines. For example, an art history student's question about dragon imagery blossomed into a question about medieval plants and finally resulted in study on the ethnobotany of dragon-related plants. Many described increased confidence in their ability to think critically and share that thinking across disciplines. Alumni reported the ability to accept and respond to constructive criticism as one of the most transformative gains of working on the cross-over exhibit.

Long-term Viability of the Project

A student research legacy was established by this unique and complex project. Alumni come to events, present at conferences, and maintain professional contact to the project; a sense of pride is felt by the individual and the group as the exhibit and festivals evolve. It remains "our" project rather than something someone once participated in. The result of this maintained membership has been momentous in a number of ways. The former student researchers continue with the project from their adult perspectives. They are in graduate school or establishing careers and those experiences come with them, broadening and deepening the project. One example of this phenomenon is a creative writing graduate student who completed an internship with the project, creating a website and completing a sequel for the children's book she wrote at an earlier stage of the project. A second example is a student who graduated and continued to work with the natural history museum prior to attending school for veterinary medicine.

Every project iteration has generated more partners. This expansion has required the original primary investigators to maintain a flexible and inclusive environment that welcomes everyone to the inquiry of the group. No one is forced into a specific direction; rather, they are encouraged to bring forth the ideas that make the most sense to them. The

lines of inquiry appear boundless at this point [30].

4 Discussion

Transdisciplinary pedagogies are well established in several domains. The medical field began using it to better replicate real-world practices and to teach problem-solving processes using challenges that have more than one solution [31-33]. The engineering field followed suit for similar reasons, needing to address issues that had many stakeholders [34-35]. The environmental sciences adopted its practice in order to attack multidimensional problems that have no easy solution [36-37]. It is clear that transdisciplinarity is being used in some of the most challenging environments. Extending it more deeply into academia makes sense if we are to prepare students for the messy problems they will invariably encounter [38-39].

The literature also tells us that real-world application of transdisciplinary processes comes with challenges [40-41]. For detractors, the work generated ranges too far afield to be called by its traditional, disciplinary label: science, humanities, art [42-44]. Others, operating from a territorial perspective, may call into question the scholarly competence of transdisciplinary practitioners [45]. Conversely, those who have successfully engaged in transdisciplinary projects find that they reflect a comprehensive way to address complex questions, allowing the researchers to put out destructive fires while fanning the flames of generative ones [46-48].

A common model in undergraduate science laboratories is for a student to be given a small part of the mentor's larger project. Together with other science students, they work to answer a focused research question. This project is similar in that focus on an initial research question exists; yet, it is different in that this model allows students to work with a vast array of students and scholars across many disciplines to answer the divergent research questions that continually arise from the original question [49]. In the DRC, students take ownership of their work and proceed independently, all the while remaining accountable to the larger group and the importance of their part within the whole machine [50]. This transdisciplinary training prepared them for a world where problems are not set up for them and facilitated the integrated collaborative work that Pennington et al. [51] describe as trans-

formative. Whether they aspire to graduate school or career, the skills they take with them help insure that they can interact productively.

Scientists must work with others thinking outside of traditional realms where some of the most exciting research is being done. This larger brain trust works best when all of the players are secure and confident enough to come to the table with their ideas and work in a synergistic manner [52-53]. One of the most important practical outcomes of this project has been connecting its arts-science content to such a wide variety of people. Finding ways to bring fossils, culture, and plant biology to the community outside academia, even if briefly, is an accomplishment. Making that information engaging and accessible in the hopes that the audience will continue to seek additional details is what keeps the researchers moving forward [54]. The DRC's work with the exhibit and the emergent dragon festivals has sparked an interest in science that is accessible to the community. Exposure to art, folklore, and history was linked to the sciences in a way that showed the visitor that all are connected. The non-traditional approach to a natural history museum festival brought in visitors from new sub-populations that had never visited the museum. In addition to this increase in visitors, the number of new institution memberships purchased at the event represented 25% of the year's memberships. A previously unrepresented group now visits the natural history museum regularly. Dragons may have been the topic, but science knowledge is what the exhibit delivered - the ultimate fire power!

5 Conclusions

Overall, this project showcases how a large, transdisciplinary research project can generate a cohesive community to engage with a complex problem. The method can be applied to any number of situations, for example but not limited to, environmental concerns, community heritage, and disease control. Finding ways to bring in a larger group of stakeholders ensures that the necessary buy-in is obtained for future success. During the process, abundant opportunities for deeper and wider learning, in formal and informal educational settings, are born.

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About the Authors



Dr. DorothyBelle Poli is an evolutionary biologist who specializes in the plant physiology of phytohormones, but she also has a research focus on Carboniferous fossil plants. Poli's interests in the living world are enhanced by her fossil work. Currently Poli is an Associate Professor of Biology at Roanoke College where she teaches cell biology, evolution, and plant diversity. She also is a Research Assistant at the Virginia Museum of Natural History in Martinsville, VA where she studies the Commonwealths paleobotany collection.



Dr. Lisa Stoneman is a social scientist whose specialty is English pedagogy. Her interests also include transdisciplinary educational practices and folklore, particularly that of the Celtic and Appalachian regions. She is currently involved in several research projects that bridge education, folklore, and science. Dr. Stoneman teaches secondary level pedagogies and general education courses, as well as supervising students in the field for the Education Department at Roanoke College.

Together Stoneman and Poli are examining the connection between lycopod fossils and dragon folklore. This work began in 2013 after Stoneman heard Poli present her research into the fossils and the living lycopod characteristic of producing explosive fire. Their interest in how folktales may have arisen from ancient peoples perceptions of the natural environment quickly led the two to create the Dragon Research Collaborative which continues to evolve.