BRAIN BASED LEARNING IN INTERPRETIVE EXHIBIT DESIGN

A FIELD PROJECT

Presented in Partial Fulfillment of the Requirements for the

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By

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Acknowledgements

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Dedication

This thesis is dedicated to my wife, Melissa Curry. Without her support and encouragement it never would have happened.

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Chapter 1

Introduction

Background

Nature centers and similar facilities are usually designed and used as multipurpose buildings. The buildings may act as a lunchroom, restroom, rental space, storm shelter, office space, library, or a gift shop. The buildings usually have one other important purpose, usually the primary reason for the facility. That is education. Specifically, a kind of informal education called interpretation.

According to the National Association for Interpretation, "Interpretation is a mission-based communication process that forges emotional and intellectual connections between the interests of the audience and the meanings inherent in the resource" (2009). Interpretation can take on two forms depending on how the interpretive message is delivered. The first is called personal interpretation. Personal is the key word, since another person is directly involved to provide the education (NAI Definitions Project, 2007). This could range from an evening program by a park ranger to a naturalist who answers questions for a curious visitor. The second form is called nonpersonal interpretation. This is media used to convey the message (NAI Definitions Project, 2007). It might be a pamphlet, a roadside kiosk, an exhibit, or some other form of media used to teach about natural and cultural history. Both forms can be found inside of a nature center.

Nonpersonal interpretation housed within a nature center might represent the best chance to deliver an educational message to visitors. According to the National Park Service, 40% more visitors come in contact with nonpersonal interpretation compared to personal interpretation (Caputo, Lewis, and Brochu, 2008). Considering the difference in exposure, nature centers should strive to offer quality interpretive exhibits, pamphlets, and other forms of media such as smartphone applications.

The personal and nonpersonal interpretation that occurs at a nature center is considered education. Maarschalk (1988) describes the education that goes on in this fashion as nonformal and informal. They are different from formal education in several ways. Formal education takes place in a school, includes assessment, attendance is expected, and motivation can be extrinsic. According to Tamir (1990) nonformal and informal education have no formal assessment, attendance is voluntary, and learners tend to be intrinsically motivated. Nonformal education usually takes place at a non-school type institution (such as a nature center) and is prearranged while informal education can happen anywhere and is spontaneous (Tamir, 1990). The opportunity for nature centers to educate the public usually presents itself as nonformal education.

The prearranged learning environment inside of a nature center allows for exhibits and even the building itself to educate visitors. However, to be successful, this requires careful planning. Often exhibits are designed with interpretive themes in mind (Brochu, 2007). Once interpretive themes are established, Brochu (2007) suggests following her 5M methods for addressing management, markets, message, mechanics, and media to

make a successful design. Bitgood (2000) stresses the importance of well-designed labels for exhibits. Many modern exhibits make use of interactive technology (Adams, Luke, & Moussouri, 2004). Touch screen technology and digital displays have become common exhibitory tools. These factors remain important when considering exhibit design.

Work in the field of interpretation has guided the design of these exhibits through designers' use of current trends and research, recently including brain-based research. Education of all types can benefit from the knowledge gained by studying how our brains learn. Research in the fields of educational psychology, molecular biology, evolutionary biology, and anatomy has made insights into how learning works at the level of the brain (Medina, 2009). These insights can cause educational reform in how we learn and the tools we use to enhance learning. This project seeks to use brain based learning as the predominant theory to design interpretive exhibits.

Purpose Statement

The purpose of this project is to design three interpretive exhibit plans for a medium sized nature center (approximately 1000 square feet total).

Objectives

1. This project will use evidence based research to guide exhibit design and planning, emphasizing brain based learning theory.
2. This project will design three exhibit plans for a nature center.

Definition of Terms

Exhibit

Constitutive: An organized arrangement of text, graphics, and objects that communicate a message or theme. Outside exhibits are often called waysides and may include interpretive signs, kiosks, or other presentation methods developed for use in the outdoors (NAI Definitions Project, 2007).

Operational: An organized arrangement of text, graphics, interactive technology, and objects that communicate a message or theme relevant to a medium sized, nature center.

Interpretation

Constitutive: Interpretation is a mission-based communication process that forges emotional and intellectual connections between the interests of the audience and the meanings inherent in the resource (National Association for Interpretation, 2009).

Nature Center

Constitutive: A facility that brings environments and people together under the guidance of trained professionals to experience and develop relationships with nature. A nature center serves its community and fosters sustainable connections between people and their environment (NAI Definitions Project, 2007).

Limitations

- This project only seeks to design, not fund or construct interpretive exhibits.
- The design is site specific and not known how adaptable it will be to other sites.

- The effectiveness of the plan as an interpretive tool is beyond the scope of this project and consequently will not be formally evaluated to determine actual efficacy.

Assumptions

- Interpretive exhibits are an appropriate use of nature center space.
- Interpretive exhibits are an effective way of delivering an organization's message.

Significance

Nature centers are important facilities for providing nonformal education about the natural world. They are more accessible than many outdoor locations. They are also available during seasons when outdoor activities might be less desirable or times of inclement weather. These factors make exhibits important as one of the main means of education. The importance of well-designed exhibits coupled with the ever changing world of technology make exhibit design a fluid and evolving process. There are always many variables to consider when creating new exhibits. This project seeks to identify and blend variables from both interpretation and brain based learning theory to design interpretive exhibits that would be used in a medium sized nature center.

Chapter 2

Review of Literature

This chapter will provide a basic overview of considerations for interpretive exhibits. The review of literature will begin with interpretation. Next, the review will examine educational theories that provide interpretation with its theoretical grounding. Finally, brain based learning theory will become the focus.

Interpretation

Interpretation, as defined by the National Association for Interpretation, "is a mission-based communication process that forges emotional and intellectual connections between the interests of the audience and the meanings inherent in the resource" (2009). It is often used by agencies such as nature centers, parks, zoos, museums, and botanical gardens as an informal way to educate visitors with varying wants and needs in a free-choice setting (Falk and Deirking, 2000).

Interpretation can take several different forms. There are interpretive programs and interpretive products. The two most basic divisions of interpretation are personal and nonpersonal. Interpretation may also be formal or informal (Definitions Project, 2007).

Interpretive programs are typically interpreter conducted activities. They may be lectures, hikes, audiovisual presentations, or other scheduled interpretive opportunities for visitors attend. Interpretive products are non-living items that offer interpretive

information. These may manifest as signs, brochures, maps, videos, or items like artifacts and props to enhance visitor learning.

Personal interpretation involves an interpreter or interpreters and the audience (NAI Definitions Project, 2007). Examples of personal interpretation include guided hikes, other guided tours such as those found at historical sites, and evening programs (Ham, 1992). Nonpersonal interpretation involves the visitors and an interpretive product to deliver the message (NAI Definitions Project, 2007). Examples of nonpersonal interpretation include taking time to read interpretive signs, brochures, and maps or through the use of some sort of technical device such as a smartphone (Ham, 1992).

Interpretation can also be divided into formal and informal interpretation. Formal interpretation may be active or passive. It involves a theme and a thoroughly researched topic. These are highly developed interpretive programs and products. Informal interpretation is spontaneous interpretation provided in response to a visitor's questions about the resource (Definitions Project, 2007). Due to the range of possible questions a visitor may ask, a theme is not always possible. In fact, visitor questions may be far outside the realm of what professional interpreter deals with on a regular basis.

Foundations

Since Freeman Tilden's original examination of National Park Service (NPS) interpretation, several other people have worked to advance the field (1957). Larry Beck and Ted Cable updated Tilden's principles for the 21st century (Tilden, 1957), Sam Ham identified four qualities that distinguish interpretation (Ham, 1992), and William J. Lewis

authored a text to help interpreters in parks (Lewis, 1980). The fields of psychology and environmental education have advanced interpretation by examining what makes learning most effective. All of these combined efforts have helped to make interpretation what it is today.

Principles of Interpretation

Freeman Tilden was the first to critically examine the field of interpretation. He travelled to many National Parks and examined the interpretation he saw in each. After reflection on what made the interpretation educative he witnessed "excellent, good, fair, and unsatisfactory" approaches to visitor learning (Tilden, 1957, p. 26), he created his six principles of interpretation (Tilden, 1957). The principles resulting from this process were:

1. Any interpretation that does not somehow relate what is being displayed or described to something within the personality or experience of the visitor will be sterile.
2. Information, as such, in not interpretation. Interpretation is revelation based upon information. But they are entirely different things. However, all interpretation includes information.
3. Interpretation is an art, which combines many arts, whether the materials presented are scientific, historical, or architectural. Any art is in some degree teachable.
4. The chief aim of interpretation is not instruction, but provocation.

5. Interpretation should aim to present a whole rather than a part, and must address itself to the whole man rather than any phase.

6. Interpretation addressed to children should not be a dilution of the presentation to adults, but should follow a fundamentally different approach. To be at its best it will require a separate program.

These principles have guided interpreters for decades and continue to do so today.

In 1998, Larry Beck and Ted Cable updated Tilden's original work to modernize it for interpreters today. They created fifteen principles of interpretation. The first six are simply Tilden's principles with updated language. For example, the phrase "whole man" became "whole person" in Beck and Cable. The other nine principles are new and address growth and change within the field. Beck and Cable's (1998, p. 8) fifteen principles of interpretation are:

1. To spark an interest, interpreters must relate the subject to the lives of visitors.

2. The purpose of interpretation goes beyond providing information to reveal deeper meaning and truth.

3. The interpretive presentation – as a work of art – should be designed as a story that informs, entertains, and enlightens.

4. The purpose of the interpretive story is to inspire and to provoke people to broaden their horizons.

5. Interpretation should present a complete theme or thesis and address the whole person.

6. Interpretation for children, teenagers, and seniors – when these comprise uniform groups – should follow fundamentally different approaches.

7. Every place has a history. Interpreters can bring the past alive to make the present more enjoyable and the future more meaningful.

8. High technology can reveal the world in exciting new ways. However, incorporating this technology into the interpretive program must be done with foresight and care.

9. Interpreters must concern themselves with the quantity and quality (selection and accuracy) of information presented. Focused, well-researched interpretation will be more powerful than a longer discourse.

10. Before applying the arts in interpretation, the interpreter must be familiar with basic communication techniques. Quality interpretation depends on the interpreter's knowledge and skills, which should be developed continually.

11. Interpretive writing should address what readers would like to know, with the authority of wisdom and the humility and care that comes with it.

12. The overall interpretive program must be capable of attracting support – financial, volunteer, political, and administrative – whatever support is needed for the program to flourish.

13. Interpretation should instill in people the ability, and the desire to sense the beauty in their surroundings – to provide spiritual uplift and to encourage resource preservation.

14. Interpreters can promote optimal experiences through intentional and thoughtful program and facility design.

15. Passion is the essential ingredient for powerful and effective interpretation – passion for the resource and for those people who come to be inspired by the same.

Interpretation

In 1992, Sam Ham published a textbook on interpretation, *Environmental Interpretation*. In the book Ham made important distinctions between interpretation and formal education (Ham, 1992). The biggest difference is the nature of the audience. Formal education has a captive audience, while interpretation has a non-captive audience (Ham, 1992).

Captive audiences are distinguished by involuntary participation, fixed time commitments, external rewards, and paying attention even if bored (Ham, 1992). They have motivations such as grades, diplomas or certificates, licensures, money, and employment advancements (Ham, 1992). Often captive audiences are in classrooms, job training courses, professional seminars or the like (Ham, 1992).

In contrast, non-captive audiences are voluntary, have no time commitments, internal rewards, and the choice to switch attention to something else if they are bored (Ham, 1992). They are motivated by interest, fun, self-improvement or enrichment, a better life, and entertainment (Ham, 1992). The settings for non-captive audiences are

usually parks, museums, and anywhere one watches television, listens to the radio, or reads for pleasure (Ham, 1992).

Ham concluded that due to the nature of the interpretive audience, interpretive programs have to take specific measures to ensure that the audience does not simply get up and walk away. According to Ham interpretation must be four things: pleasurable, relevant, organized, and thematic (1992).

William J. Lewis provided three texts to guide park interpreters and their supervisors. *Interpreting for Park Visitors* is a short book detailing interpretation basics for new interpreters (Lewis, 1980). He also provided structure for interpretive supervisors. Until then supervisors could provide feedback based on Tilden's principles and their own interpretive experiences. Lewis provided formal structure for what would become known as interpretive coaching with his video *Reaching for Excellence: the Process of Interpretive Critiquing* (Lewis, 1994).

Interpretive Design

In their 2008 book *Interpretation by Design* Paul Caputo, Shea Lewis, and Lisa Brochu lay out some fundamentals for designing interpretive exhibits. They suggest using complementary colors, "those found opposite each other on a color wheel", for "maximum contrast" and "the boldest look" (Caputo, Lewis & Brochu, 2008, p. 27). Analogous or adjacent colors on the color wheel are used for "creating a subtle, soothing look (Caputo, Lewis & Brochu, 2008, p. 27). Two, consistent typefaces are suggested for two distinct functions (Caputo, Lewis & Brochu, 2008). "Serif, which should be used for

body text, and… sans serif, to provide contrast… in a title or subtitle" (Caputo, Lewis & Brochu, 2008, p. 30). Appropriate illustrations and photographs enhance design but "clip art is evil" (Caputo, Lewis & Brochu, 2008, p. 43). Caputo, Lewis, and Brochu suggest laying out the design of text and images in a hierarchical fashion (2008). First, focus on the primary element or "attention grabber" (Caputo, Lewis & Brochu, 2008, p. 45). Most likely, this is a photograph, but it could be a very short, large typeface set of text (Caputo, Lewis & Brochu, 2008). The secondary element is "supporting text or images (that) make up the bulk of the communication" (Caputo, Lewis & Brochu, 2008, p. 46). Finally, tertiary elements provide information, like names of books or websites, to allow the visitor to dig deeper (Caputo, Lewis & Brochu, 2008). Once the text and images for the elements have been determined, the final layout should use a grid to "organize information in a useful and visually appealing way (Caputo, Lewis & Brochu, 2008, p.49).

Technology is also an important consideration for design. Many exhibits today use touch screen technology, Quick Response or QR codes, tablets, smartphones, or various software applications. Their integration into design is useful to reach a wider audience.

Theoretical Grounding

Work from outside the field of interpretation has helped ground it theoretically. Specifically, learning theories such as the theory of multiple intelligences and

environmentally responsible behavior can explain what can make interpretation effective. These same principles influence exhibit design.

Theory of Multiple Intelligences

Good interpretive exhibits have always appealed to people in many ways, and given them several opportunities for optimal learning. These exhibits may include items such as pictures, text, audio, movable parts, and integrated technology. The success of exhibits like this can be attributed to the theory of multiple intelligences (Gardner, 1987, 1989). Howard Gardner theorized that human beings learn in different ways through a variety of intelligences (1987). The nine intelligences identified by Gardner are visual-spatial, verbal-linguistic, logical-mathematical, bodily-kinesthetic, musical-rhythmic, interpersonal, intrapersonal, naturalistic, and existential (1987).

An interpretive exhibit utilizing multiple senses would appeal to a variety of intelligences. For example, an audiovisual portion would appeal to learners with strengths in both visual-spatial and verbal-linguistic intelligences. However, if that same exhibit added movable portion or game the bodily-kinesthetic would be stimulated as well. Exhibits that are intentionally designed to stimulate as many intelligences as possible are grounded in the theory of multiple intelligences.

Environmentally Responsible Behavior

Among the goals of interpretation is fostering stewardship behaviors toward the resource in visitors. Human behavior is complex, and the motivations for such behaviors can often be unclear. In order for interpretation to foster stewardship it is important to

know what affects behavior. The theory of environmentally responsible behavior offers insight into this issue.

Hines, Hungerford, and Tomera (1986/87) searched for variables that can affect environmentally responsible behavior. They categorized the variables they investigated as cognitive variables, psycho-social variables, demographic variables, and behavioral intervention or classroom strategy variables . Hines, Hungerford, and Tomera identified six variables that can affect environmentally responsible behavior and proposed a model to describe it (1986/87) (see Figure 1).

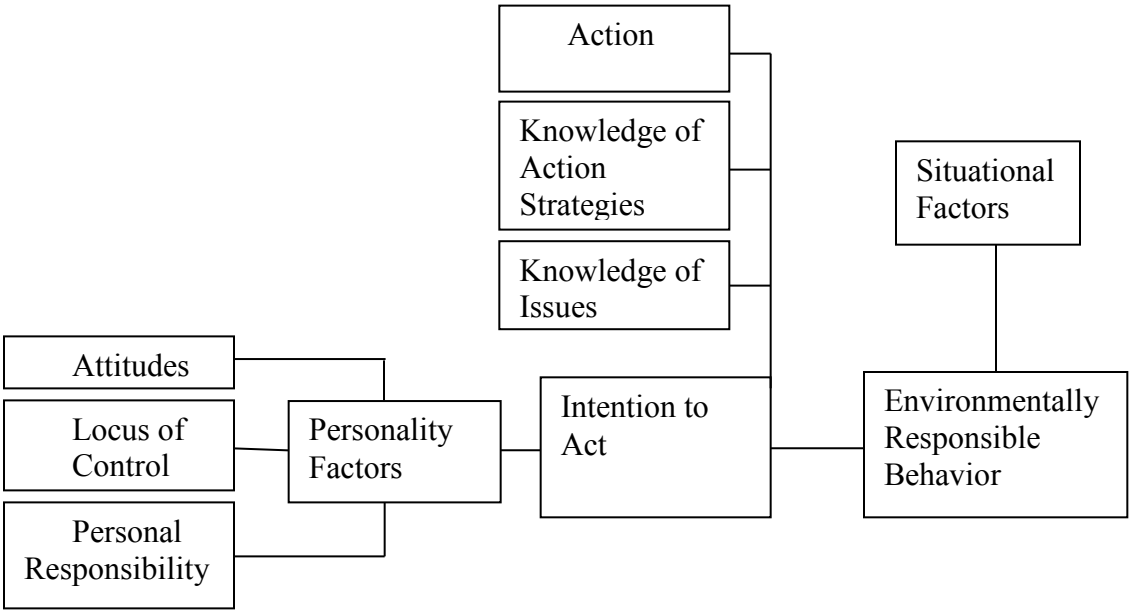

Figure 1. Model of Environmentally Responsible Behavior (Hines, Hungerford, & Tomera, 1986/87).

Attitudes, locus of control, and personal responsibility are all variables comprising the "personality factor" (Hines, Hungerford, & Tomera, 1986/87). The variables action skills, knowledge of action strategies, and knowledge of issues all interact with the "personality factors" to create an intention to act (Hines, Hungerford, & Tomera, 1986/87). This intention to act and the situational factors present can result in environmentally responsible behavior (Hines, Hungerford, & Tomera, 1986/87).

Stephen Kaplan proposes that human motivations can be a strong predictor of environmentally responsible behavior (2000). Three factors affecting this have strong ties to interpretation. One, people are motivated to know, to understand what is going on (S. Kaplan & R Kaplan, 1989). They dislike being confused (S. Kaplan & R Kaplan, 1989). This is important for interpretation because of the non-captive nature of the audience. The motivation to know and understand is important for keeping visitors interested in the interpretive tool being used. Two, people are motivated to learn, to discover, to explore (S. Kaplan & R. Kaplan, 1989). This motivation is important for interpretation, especially exhibits. Third, people want to participate, to play a role, in what is going on around them; they dislike feeling incompetent or helpless (S. Kaplan & R Kaplan, 1989). This type of motivation speaks to the strength of interactive interpretation. Interactive technology and games featured as part of an interpretive exhibit intentionally invite people to participate and play a role (Purkey & Novak, 1996).

The work of these researchers coupled with the work of Tilden, Ham, Lewis, Beck, and Cable has given interpretation its current procedures and practice. Their work is also guiding the future of interpretation, including interpretive exhibits.

Brain Based Learning

Brain based learning is the junction of how brains actually function and how education is conducted. Glisczinski (2011) describes it as "time-honored learning cycle theories in relationship to current brain research." To Glisczinski this is lighting up the mind, a reference to neuroimaging.

The neuroscience behind brain based learning can be daunting. With proteins like brain derived neurotrophic factor and seemingly endless cortices and stimuli (Doidge, 2007; Restak 2009; Sousa, 2006; Zull 2002; Zull 2006), it helps to have a guide. John Medina sets up 12 guidelines with his 2008 book *Brain Rules*. All of the rules are based on research "published in a peer-reviewed journal and then successfully replicated (Medina 2008, p 3). The 12 rules are listed below.

1. SURVIVAL: The human brain evolved, too.
2. EXERCISE: Exercise boosts brain power.
3. SLEEP: Sleep well, think well.
4. STRESS: Stressed brains don't learn the same way.
5. WIRING: Every brain is wired differently.
6. ATTENTION: We don't pay attention to boring things.
7. MEMORY: Repeat to remember.

8. SENSORY INTEGRATION: Stimulate more of the senses.
9. VISION: Vision trumps all other senses.
10. MUSIC: Study or listen to boost cognition.
11. GENDER: Male and female brains are different.
12. EXPLORATION: We are powerful and natural explorers.

Survival

Human brains have shaped and been shaped by natural selection. They possess four characteristics that aid this process (Medina, 2008).

First, the human brain is actually three brains in one (Nitrecki & Nitrecki , 1994). A lizard brain or brain stem keeps us alive. It is responsible for things like breathing and heart rate (Medina, 2008). The mammalian brain consists of the amygdala, hippocampus, and thalamus (Nitrecki & Nitrecki , 1994). This part of the brain is responsible for emotion, sensory input, and memory (Medina, 2008). Lastly, the human brain or cortex, is an interconnected web of electrical information (Nitrecki & Nitrecki , 1994). It allows for complex actions, such as human speech (Medina, 2008).

Another characteristic that helped with survival was the ability to make stuff up or use symbolic reasoning (Medina, 2008). This dual representation (DeLoache, 2004) is why we have language, music, and art. Dual representation can make a pair of crossed sticks be a lower case t, an x, a symbol to add or multiply, a religious cross, or any other representation ascribed to it. Symbols, especially warnings, increased survival (Medina, 2008).

A third characteristic is that we adapted to variation itself (Potts, 1998). The climate changed. Habitats changed. In order to survive, the brain had to handle these changes with quick problem solving. This environment led to the creation of tools (Arp, 2006).

The final characteristic that led to survival is the size of the human brain. The driving force behind brain size was the adaptation to walk on two legs (Steudal, 1994). It was more energy efficient, freed up the hands for tools, and allowed for the development of the prefrontal cortex. The prefrontal cortex is responsible for executive functions like problem solving.

Exercise

Exercise has been shown to have a strong influence on the brain. It has two main physiological effects. Exercise increases oxygen flow to the brain and changes the molecular nature of the brain (Medina, 2008). The increased oxygen in the brain improves cognitive function (Scholey, 1999). One molecular change caused by exercise is an increase in brain-derived neurotrophic factor (Vaynman, 2006). BDNF is a protein that not only helps connect and maintain current neurons, it also aids in neurogenesis.

In addition to the critical physiological functions noted above, exercise has been shown to have myriad positive effects on the brain. It reduces depression (North 1999; Barbour and Blumethal, 2005), affects academic achievement (Dwyer, 2001), cuts the risk of Alzheimer's (Rovio, 2005), and helps an aging brain with memory and alertness (Emory, 1995; Churchill, 2002; Kramer, Erickson, and Colcombe, 2006).

Sleep

Not getting enough sleep negatively affects brain function. According to Medina (2008), "Sleep loss hurts attention, executive function, working memory, mood, quantitative skills, logical reasoning ability, general math knowledge. Eventually, sleep loss affects manual dexterity, including fine motor control, and even gross motor movements, such as the ability to walk on a treadmill." Sustained sleep deprivation is even worse. Cognitive function was shown to decrease 30% after the first night of sleep deprivation and 60% and the second consecutive night (Angus and Heslegrave, 1985).

Stress

Severe stress negatively affects brain function. According to Medina (2008), the "villain" is cortisol, a glucocorticoid hormone released by the adrenal glands. Stress and its associated hormones hinder declarative memory (Newcomer, 1999) and executive function (Keinan, 1999). Stress can even kill cells in part of the brain (Sapolsky, 1985).

Wiring

Learning affects the wiring of the brain causing neurons to physically change. First, neurons swell during the learning process (Fikova & Anderson, 1975). Second, neurons split during the learning process (Geinisman, 2001). Third, neurons actually move during the learning process (Lamprecht & LeDoux, 2004).

Attention

Attention is necessary for learning. However, attention only lasts about 10 minutes without the need to reengage (Hartley & Davies, 1978). Attention is also acutely

focused. Multiple studies have shown how poor human brains are at paying attention to multiple things (Rubenstein et al., 2001; Ramsey et al., 2003). Lastly, emotional components positively affect attention (Dolcos, 2004).

Memory

Repetition is key for memory. Simply repeating information, known as maintenance rehearsal, helps with short term memory (Peterson & Peterson, 1959). Without repetition a brain can only hold onto something for about 30 seconds (Miller, 1956). Talking over something or elaborative rehearsal helps long term memory (Gardiner, 1994). The timing of the repetition is also important. Spacing repetitions out improves recall (Wagner et al., 2000; Eichenbaum, 2004).

Sensory Integration

The senses play a large role in learning and memory. The brain responds better to multiple senses than to one sense. Mayer (1997) showed that students who had a multisensory presentation performed 50% to 75% better than students who had presentations using just one sense. Senses benefit from other senses stimulating the brain at the same time (Lovelace et al., 2003). The sense of smell is extremely powerful when it comes to memories. The reason behind this may have to do with how the neurons are wired. Other senses are wired through the thalamus, which acts as a gatekeeper to the rest of the brain. Smell, however, skips through the thalamus and is wired directly to the amygdala (Gottfried et al., 2004). The amygdala is responsible for both emotion and memory.

Vision

"Vision is king," according to Medina (2008). He also notes that almost half the brain's resources are used for vision. Perhaps that is why it affects memory so much. In one study, people were shown 2,500 pictures for 10 seconds (Standing et al., 1970). Several days later they remembered the pictures with 90% accuracy (Standing et al., 1970). In a study conducted by the United States Air Force, subjects recalled images with 63% accuracy a year later (Nickerson, 1968).

What the subject is seeing is also important. Several studies have shown that pictures are superior to words (Endestad et al., 2003; Mcbride & Dosher, 2002; Stenberg, 2006). Researchers believe this is because the brain views the letters within a word separately, interpreting each as a distinct picture (Pelli et al., 2003).

Music

Listening to music affects the brain. Listening to music can change the chemistry of the brain. The neurotransmitter dopamine is released when stimulated by music (Salimpoor et al., 2011). The hormone oxytocin, which influences social bonding, is released when people make music together (Grape et al., 2002). The hormone cortisol is responsible for stress. Trappe (2010) found that surgery patients who listening to music during surgery had 13% less stress as measured by the study than patients who took a stress lowering pharmaceutical.

Gender

The male and female brains are different in both structure and function. Females have been found to have a larger prefrontal cortex, a key decision making center in the brain (Goldstein et al., 2001). Conversely, the amygdala, which processes emotion and memory is larger in males (Goldstein et al., 2001). The chemistry is different too. Males create the neurotransmitter serotonin, which affect emotions 52% faster than females (Nishizawa et al., 1997). Besides the size difference, the amygdalae function differently as well. When stressed males use the side of the amygdala responsible for remembering the gist of an event while females use the side which focuses on details (Cahill et al., 2004).

Exploration

Our brains work by exploration. Observation, hypothesis, experiment, and conclusion are not just the scientific method, but also represent how babies learn (Medina, 2008). For this very reason, Gopnik (1996) referred to the human child as "the best learner on Earth." Exploration and learning don't end with childhood. For a little over a decade, scientists have known that regions of the brain where learning takes place keep making brain cells (Jacobs & Fehlings, 2003).

Conclusion

From the beginning of interpretation with Freeman Tilden over half a century ago to the newest in neuroscience research informing how brains learn, the design of exhibits for nature centers is always changing. The foundations built by Tilden, Sam Ham,

William J. Lewis, Larry Beck, and Ted Cable should not be forgotten. Instead, they should serve as a ground floor to influence design. Research in other fields should then be blended to guide the design. For example, Gardner's work on multiple intelligences in 1987 coupled with Mayer's 1997 work on multisensory presentations would both be instructive to exhibit design in similar ways. Both sets of research would indicate an exhibit with graphics, sounds, and texture for touch would be far better than simply text or graphics.

Chapter 3

Methods

This project has identified a nature center site, explored the goals and techniques of the site, documented the current exhibits and displays, and designed three new interpretive exhibits based on the goals of the site. The new exhibits were designed with an emphasis on brain based learning first and interpretation principles second. Specific "rules" from Medina (2008) were selected to guide the design. Some "rules" like those about sleep are beyond the control and scope of an interpretive exhibit. This project had two primary goals: to design a functional plan for implementation at a tallgrass prairie site in Iowa, and second, to provide clear guidelines for the reader to design exhibits for their own site.

Site Specifics

History

Indiangrass Hills is 752 acre prairie and woodland restoration and preservation site in Iowa County, Iowa. The acquisition of the site began with 480 acres in 1997. Adjacent plots have been added to the site as they became available. Prior to restoration work approximately half of the site was used agriculturally for row crop production or pasture. The rest of the site was deemed too hilly, too remote, or containing soil too poor to plow. The site consists of a few buildings, reconstructed prairie, remnant prairie, oak-hickory-walnut forest, and silver maple-cottonwood lowland forest. The site is an Iowa

Important Bird Area as designated by the Audubon Society. It is currently managed by landowners operating with reserve life estates. Eventually, the management will be turned over to the Iowa Natural Heritage Foundation who received it via donation in 2005.

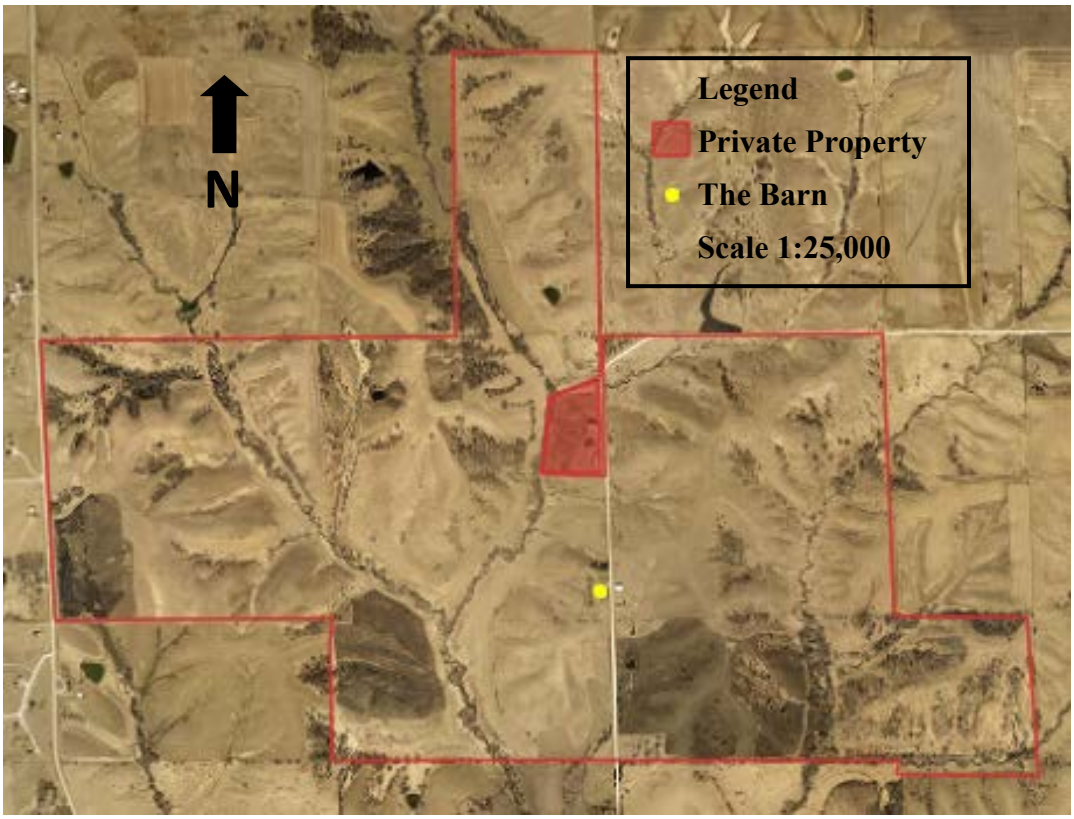

Figure 2. Map of Indiangrass Hills, rural Iowa County, Iowa.

Facilities

There are a few buildings at Indiangrass Hills. The Barn (see *Figure* 3) is the center of operations. A nearby loafing shed is used for the storage of firewood and fencing supplies. Several old farmstead structures can also be found on the property.

The Barn is the de facto nature center. Like most nature centers it is a multiuse facility. It is located next to the parking area and typically the first thing most visitors will see upon arrival. Equipment for restoration work including chainsaws, UTVs, a tractor, herbicide, and seed harvesting equipment is housed on one side. The other end is home to simple prairie exhibits, a small library of identification books and manuals, and pictures chronicling the history of the site. There is a refrigerator and running water but no kitchen or restroom. It is functional but spartan.

Figure 3. The Barn at Indiangrass Hills.

Management Goals and Techniques

The main goal of Indiangrass Hills is to use land management techniques to return the area as closely as possible to its pre-settlement condition. The landowners wanted to show the even previously degraded agricultural land was not beyond restoration. They also believe that ordinary people (perhaps with extraordinary determination) can make a real difference. They also believe in knowing nature through identification of plants and animals. The most common land management techniques utilized at Indiangrass Hills are prescribed fire, native seed harvest and planting, invasive species removal, and timber stand improvement. Each management scheme will be described below.

Prescribed Fire

Prescribed fire is one of the most important management tools used at Indiangrass Hills. This is because of the fire tolerance of many native species. When restoration work first began, several former pastures with little to no visible prairie species left were burned. Amazingly, prairie plants suppressed for decades returned as the seed bank responded. The pastures began to show more and more prairie species as time and the reintroduction of fire did their work on the land.

The prescribed burns at Indiangrass Hills are planned, conducted, and recorded with restoration as the goal. For example, the entire property is broken up into distinct burn units. Some plants favor spring burns while others favor fall burns. The site scheduling of each burn is rotated. That keeps each burn unit diverse in species and prevents species that favor one season or the other from overwhelming the site. Special

attention is also paid to the weather. If the humidity and temperature are out of range a burn may consume too little or too much. Patchy burns are preferred since they provide refugia for invertebrates. Each burn is recorded and kept at the Barn. The information includes the date, weather data, crew information, and a map highlighting which area was burned. These maps make up a jigsaw sort of exhibit in the Barn allowing visitors to see the rotation of burn units throughout the years.

Native Seed Harvest and Planting

The prairie restoration done at Indiangrass Hills tries to be as site specific as possible with respect to seed ecotype. Other sites may purchase seeds from a nursery in another part of the state or even a different state. These purchased seeds might be from a different ecotype that performs poorly in some areas. For that reason, seeds planted at Indiangrass Hills are often harvested on site. The large area, quality of diverse habitats, and knowledgeable work crew make possible what might not be feasible or practical on another site.

There are two primary ways seed is harvested at Indiangrass Hills. One way is to pull a mechanical seed stripper (see *Figure 4*) behind a UTV. The height of the seed stripper can be set to take advantage of prairie species natural tendencies. For example, if big bluestem seeds are ready to be harvested but lower growing plants are not, the seed stripper could be set at a height of five or six feet. The big bluestem seeds would be

Figure 4. Mechanical seed stripper for harvesting prairie seed.

harvested, but those of lower plants would be left to mature. The other way to harvest seeds is by hand. Workers skilled in plant identification take buckets into the field and cut or strip seeds into a bucket. This is done on sites too small or fragile for mechanical equipment. Moreover, not all prairie seeds can be successful harnessed with a seed stripper, but all can be harvested by hand.

Once harvested, the seed is processed. Processing includes drying and removing the chaff. Processed seeds are then stored until planted either individually by species or in mixes.

The planting style done at Indiangrass Hills, frost seeding, closely mimics nature. In the fall or early winter, just before a snowstorm, the seeds are spread by hand. Sometimes this is done from a moving UTV. The idea behind frost seeding is that nature

does most of the work. The seeds are spread just before a snowfall to lower the amount consumed by local fauna. Instead of using a seed drill, a common practice for planting, the seeds fall into small cracks that naturally open during the freeze and thaw cycle. Instead of stratifying and scarifying seeds in vats of sand in refrigerator while monitoring the humidity, a common practice to improve germination, the seeds go through a natural vernalization process with winter temperatures and precipitation. The results at Indiangrass Hills, while anecdotal, have been good.

Invasive Species Removal

Invasive species removal is the most labor intense restoration technique used at Indiangrass Hills. Honeysuckle, autumn olive, multiflora rose, garlic mustard, *Conium*, crown vetch, Canada thistle, oriental bittersweet, and a few other unwanted nonnative species are actively managed for on the site.

The species listed above are worked against based on their natural history and phenological weaknesses. For example, action is taken against annuals and biennials in their second year before seed production can occur. Species like garlic mustard create an abundance of seeds that can last in the seed bank for years. Hand pulling and dormant season herbicide application can prevent seed production and slowly gain back territory. Woody species like autumn olive and honeysuckle are often treated in the fall. There are two reasons for this. The first is identification. These species hold their leaves longer than natives so they are easy to find after native leaf drop. The second reason is physiological. In the fall, phloem in these species is taking sugar filled sap to the roots. If the stem is cut

and herbicide applied, the plant sucks the poison down, dooming itself. Conversely, a similar method would not work in the spring. The flow is reversed and cut stumps "weep." Herbicide applied at this time is flushed off and the plants often re-sprout from below the cut.

Timber Stand Improvement

The suppression of fire by humans has allowed fire intolerant, shade tolerant species to colonize the forest floor. Three types of timber stand improvement activities, borrowed from the field of forestry, are used at Indiangrass Hills to mimic nature and reset the forest to how it may have once been. Weed tree removal is used to take out midstory and canopy trees that are shade tolerant as saplings. Oak, the main native tree in these forest types, is fairly shade intolerant and compete poorly against saplings of the other ilk. Crop tree release is a technique used to select and thin desirable trees growing at stocking rates considered too high. Crop tree release can be the difference between a stand of many poor form, sickly trees and a stand of a few healthy trees. Lastly, shelterwood cutting is used to open gaps which allow sunlight to reach to forest floor. This is usually done in an even age class areas to allow oak saplings to grow up. Felled tree are often left to preserve biomass in the forest and serve as nurse trees.

Figure 5. Examples of items currently on display: a prairie root diagram and a visual chronology of prescribed fire on the site.

Current Exhibits

The exhibits currently at Indiangrass Hills represent a smorgasbord of plant and animal pictures, animal parts, phenological information, historical documents, and article clippings (see *Figure 5*). There seems to only be minimal thought put into the flow and design of the exhibits. The exhibits are definitely more informative than interpretive. However, no one on staff has any training in interpretation. They just know that there needs to be something for visitors to look at. Also, many of the exhibits are deeply personal to the landowners. Often a conversation about an exhibit with one of them creates that interpretive spark missing when just observing the exhibit.

The exhibits include maps showing prescribed fire sites, phenological graphics depicting when certain prairie plants blooms, prairie plant identification posters, a poster depicting native frogs, quotes by famous conservationists, prairie plants and animal

posters with informative text, deer skulls and antlers, snake skins, bird nests, posters about pollinators, and a collage featuring pictures of management activities, current and former staff members, wildlife sightings on the property, and prairie plants.

Principles Used in Design

In order to design new exhibits for Indiangrass Hills, this project identified several of Medina's "rules" to guide exhibit development. Some of Cable and Beck's principles of interpretation were then layered into the design. Finally, Caputo, Shea, and Brochu's work was used to inform shared graphic elements for exhibit design.

Medina's Brain Rules

Medina's (2009) rules are powerful tools extrapolated from neuroscience research. Guiding the interpretive exhibits were the following:

- EXERCISE: Exercise boosts brain power.
- ATTENTION: We don't pay attention to boring things.
- MEMORY: Repeat to remember.
- SENSORY INTEGRATION: Stimulate more of the senses.
- VISION: Vision trumps all other senses.
- EXPLORATION: We are powerful and natural explorers (p. *i*).

Exercise was used in at least one of the exhibits. This involved traveling outside the Barn. The mode of travel will be up to the user. In spring, summer, and fall it will most likely be hiking, although trail running could be a possibility for some users. In the

winter, it will most likely take the form of cross country skiing or snowshoeing. Regardless of the mode of transportation, visitors will be searching for QR codes to scan with their cell phones.

Focus on attention was attained by appealing to emotions. Discouraging multitasking may also be possible, but could prove difficult in today's smartphone-centric world. The integration of the smartphone into at least one exhibit was used to mitigate this effect.

Memory will be helped by repetition. While the amount of time a visitor spends with an exhibit will most likely be short, deliberate attempts were made to space the repetition out to encourage memory formation. Encouraging dialogue among visitors or with staff will provide elaborative maintenance, which helps with long term memory.

Sensory integration was part of all three exhibits designed. Each design has focused on vision with touch, smell, and/or hearing playing a role as well. Each design featured at least two senses if not more.

The visual portion of each design focused on pictures. Text was used as well in a secondary role. A main picture or set of main pictures was the centerpiece, depending on the medium. Stationary, more traditional exhibits have a main picture offset by smaller complementary images. Digital exhibits have a set of main pictures that will change depending on the visitor's interaction with the device.

Exploration was an important part of on exhibit. Visitors were given the opportunity to observe, create a hypothesis, experiment, and draw conclusions.

Beck and Cable's Principles of Interpretation

Beck and Cable's principles were used secondarily to layer interpretive knowledge on top of neuroscience. Specifically, the following principles were used.

1. To spark an interest, interpreters must relate the subject to the lives of visitors.

Each exhibit related to the everyday life of the common visitor. Not only is this good interpretation, but it also spoke to the attention "brain rule."

2. The purpose of interpretation goes beyond providing information to reveal deeper meaning and truth.

The set of exhibits together, strived to reveal deeper meaning about land management and what it means to be a steward of the land. For example, fire is portrayed as destructive, but it is actually a necessary part of ecosystem management.

7. Every place has a history. Interpreters can bring the past alive to make the present more enjoyable and the future more meaningful.

The history of the site and its changes throughout time is one of the most incredible things about Indiangrass Hills. The visitor was queried to envision what the site might look like in five years?

8. High technology can reveal the world in exciting new ways. However, this technology into the interpretive program must be done with foresight and care.

The digital exhibit designed for Indiangrass Hills utilized smartphones and QR codes. Smartphones are almost ubiquitous in the world at the timing of writing. This

helped in several ways. One, most visitors already have one. This will save the site money since a hardware investment will not be needed. Second, people usually know how to use their phones. For those who aren't familiar with the application used, a simple set of directions will be available along with a test code to ensure understanding. Lastly, many people have a QR code application on their phone. The Indiangrass Hills website can add a simple statement encouraging those who don't have a QR application to download one before their visit. Visitors may also choose to download one on site through their own cellular network.

9. Interpreters must concern themselves with the quantity and quality (selection and accuracy) of information presented. Focused, well-researched interpretation will be more powerful than a longer discourse.

Each exhibit focused on a fairly small amount of information. That way visitors do not feel overwhelmed. Integrating the neuroscience research informed exhibit design so previous information is repeated rather than introducing new information.

13. Interpretation should instill in people the ability, and the desire to sense the beauty in their surroundings – to provide spiritual uplift and to encourage resource preservation.

Resource preservation on visitor owned land was the ultimate goal. However, the natural beauty of the site and the information in the diplays should be enough to uplift all visitors, landowner or not by showing the power of resource restoration.

Exhibits

This project designed three exhibits. The themes of the exhibits were based on Indiangrass Hills goals and management techniques. The exhibit design was informed by the work of Medina and Beck and Cable listed previously in this chapter. The work of Caputo, Lewis, and Brochu informed similar graphic elements shared by all three.

All Exhibits

All three of the exhibits featured similar graphics elements to tie them together. A color scheme was identified based on prairie wildflowers. The same typefaces were used throughout design for consistency. All photographs used will be taken onsite for authenticity. A five column grid design gave consistency to exhibit layout and PDFs accessed by QR codes. The grid was used in portrait or landscape orientation.

All exhibits featured contact information. It was in the same format on each exhibit. The following text was at the bottom of the fifth column.

> *For More Information*
>
> Ask a staff member for more
>
> details or contact us at:
>
> XXX-XXX-XXXX
>
> email@address

Exhibit One

This exhibit spoke to the landowners' belief in prairie restoration, large or small. Native landscaping is important even on a small scale. This exhibit encouraged native plantings at the home of the visitor.

Exhibit Two

The second exhibit focused on invasive species removal. Invasive species removal represents an entry level restoration technique. Every visitor can learn about how and why it is important. Private landowners may be more likely to try something like this on their own property as opposed to something more complex like prescribed fire.

Exhibit Three

The third exhibit involved digital media. It will shift phenologically to take advantage of nature's changes. It provided visitors a chance to see recent work, compare sites, and maybe even participate. The visitors will be actively engaged in their own learning while exploring various sites at Indiangrass Hills, a method referred to as guided discovery (Gilberston, Bates, McLaughlin, & Ewert, 2006, p. 129).

Conclusion

All three of the exhibits have a fairly complete design. This was done so the landowners can simply plug in their own preferences and the exhibit will be complete. Each design featured drafted text including suggested typeface and font size, a grid showing the location of design elements, a list of equipment to be incorporated, and a location at Indiangrass Hills for installation. A list of materials for fabrication was not

included since this aspect is beyond the scope of this project and would likely be contracted out.

Chapter 4

Results

Introduction

This chapter laid out the design of the three exhibits. The overarching graphic elements shared by the exhibits were designed first. That design was then applied to the three displays. Each design included a narrative overview, a grid for layout, and the location for installation.

The audience for these exhibits will be visitors at Indiangrass Hills. They represent a specific subset of the public. Most of them are there to volunteer or observe resource management activities. Examples of common visitors would be other landowners with an interest in restoration and volunteers doing seed harvest by hand, invasive species removal, or prescribed fire.

The exhibits were designed to appeal to these visitors. Two of the exhibits were designed to promote similar activities on a smaller scale at the visitors' homes. These two will be located in the Barn (see *Figure 6*). The other exhibit showcases different resource management activities, current and past, that the visitor can view firsthand.

Figure 6. The layout of the Barn at Indiangrass Hills. The black line represents the door and yellow lines represent the sliding equipment doors.

Shared Graphic Elements

All three designs shared similar graphic elements. These similarities linked the displays visually. The shared elements included a color scheme, consistent typefaces, and a five column grid. These design decisions were based on the work of Caputo, Lewis, and Brochu (2008).

Color Scheme

The color scheme for the designs was taken from the prairie itself. Prairie wildflowers, especially in late summer, often come in shades of yellow, purple, and white. Sunflowers, *Coreopsis*, goldenrods, partridge pea, and *Rudbeckia* provided the yellow. Asters, coneflowers, and *Monarda* occurred in various purples. And white came from other asters, fleabane, and white prairie clover. Not only are these colors present in the prairie together, but purple and yellow are also complementary colors. These colors were arranged in two distinct ways. In the first form they were all used together (see *Figure 7*). In the second form, different shades of the same color were used.

Figure 7. The basic color schemes of the designs. All three used together and as variations of shade.

In addition to the colors used as the color scheme, black was also used as a color for some text.

Typefaces

Two typefaces, one serif and one sans serif, were used on all three exhibits. The serif font, Century (abc/ABC), was used for body text. The sans serif font, Raavi (abc/ABC), was used for title and subtitles. Titles were also be bold.

Grid

A five column grid was used in the layout of the exhibits. It was used in portrait or landscape orientation dependent upon the specific application (see *Figure 8*). This grid provided simple, consistent design to all of the elements.

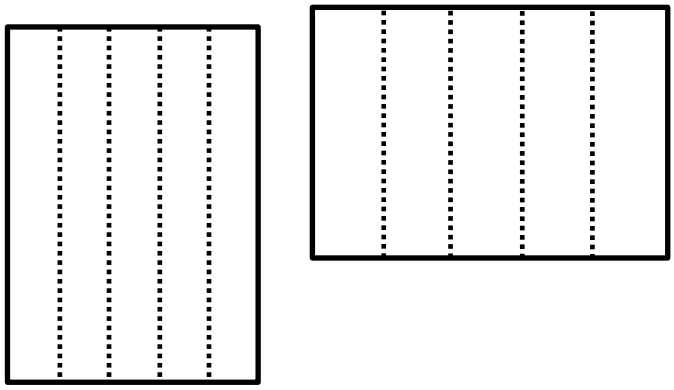

Figure 8. The portrait and landscape grid layout for use in design.

Exhibit One

Introduction

Exhibit one was intended to inspire visitors to plant prairie at home. It showed the benefits of prairie landscaping. It also gave visitors a simple set of directions and a list of vendors for prairie plants. The design included text describing the exhibit, a layout, information on the installation location, and the principles used in the design.

This exhibit was in line with the values and beliefs of the landowners at Indiangrass Hills. Specifically, it exemplified their belief that no prairie planting, even one or two plants, is too small. It also spoke to their value of do it yourself restoration.

Overview

This exhibit is called "A Prairie of Your Own" and encouraged prairie landscaping. It included a title, introductory text, a vendor list, contact information, and four sets of an object or graphic and accompanying text.

The introductory text was as follows.

> Not every prairie needs to be
>
> hundreds of acres or more.
>
> Prairie landscaping around
>
> your home helps wildlife,
>
> is low maintenance, and
>
> looks great too!

The first and second sets formed an above and below scene. The centerpiece was four preserved plants. The plants are preserved in their entirety with flowers, stems, leaves, and roots. Displaying prairie plants like this has become popular as the plant preparation used has become more available. Two of the plants were prairie plants, Indiangrass and purple coneflower. The coneflower has a preserved bee mounted on the flower. The other two plants were Kentucky bluegrass and a daylily. The four plants were lined up as if planted in the ground next to each other to show off the difference in both height and root length. The prairie plants extended above and below the display. The roots may not show entirely and ended at the floor. The plants were ordered left to right by length with the longest at the left. This created a triangular shape that will naturally pull the visitors eyes into the exhibit. All four plants were protected by their own clear plastic half cylinder. The half cylinder had a small plate to identify the plant.

The above section of the first set featured text and two graphics. The first graphic showed a forb heavy prairie in bloom with a variety of colors. The caption read, “Look at

all the colors!" The second graphic was a picture of a monarch butterfly on butterfly milkweed. The caption read, "Wildlife like monarchs need prairie plants." The pictures were stacked together with the captions on the left. The text was located to the right of the graphics and read as follows.

Why Plant Prairie?

Prairie plants look great and come
in a wide variety of colors. They
also attract pollinators to your yard.
Some pollinators like monarch
butterflies need prairie plants like
milkweed to survive.

The below section included the following text.

Why Plant Prairie?

Prairie roots run deep. That makes
them more resistant to drought
than other landscaping plants.
It also means less watering for you.
Once prairie plants are established
they require very little maintenance.

The third set provided a “how to” for planting some prairie landscaping and include a picture and text. The picture showed prairie plugs. The caption for this picture was located under it and read, “Prairie plugs ready for planting.” The text read as follows.

Prairie Plants at Home!

Prairies can be planted from seeds
or plugs. Seeds are good for
larger plantings. Plugs are better
for small plantings and landscaping.
Follow the directions from the nursery
to ensure success.

The fourth set featured a graphic consisting of four quadrants. The top left quadrant had a scene of Indiangrass Hills before restoration. The top right showed a prairie at Indiangrass Hills after restoration. The bottom left showed a house with conventional landscaping. The bottom right featured a sliding picture with a small handle and a large question mark. When the outer picture is slid away it will show the same house after some landscaping has been replaced with prairie plants. The graphic was displayed with text as shown below (see Figure 9).

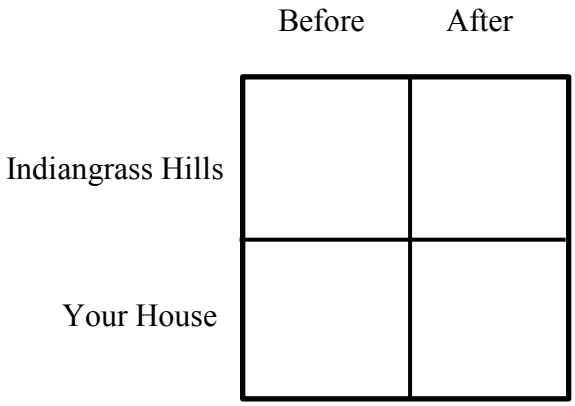

Figure 9. Layout of quadrant graphics with text.

The vendor information included the website, email address, and phone number for up to three vendors approved by the landowners. The caption "Contact These Reputable Nurseries to Purchase Prairie Seeds or Plugs" accompanied the list.

Layout

The layout for "A Prairie of Your Own" is shown in *Figure 10* below. The exhibit measured ten feet wide and five feet tall when completed. As previously mentioned, the prairie plants extended above and below the rest of the display. If the prairie roots were too long or touched the floor they were trimmed without ruining the visual comparison between them and the common landscaping plants.

Location

This exhibit will be located in the Barn at Indiangrass Hills. It will be located on the western wall near the south end. The door is on the south end of the Barn on the

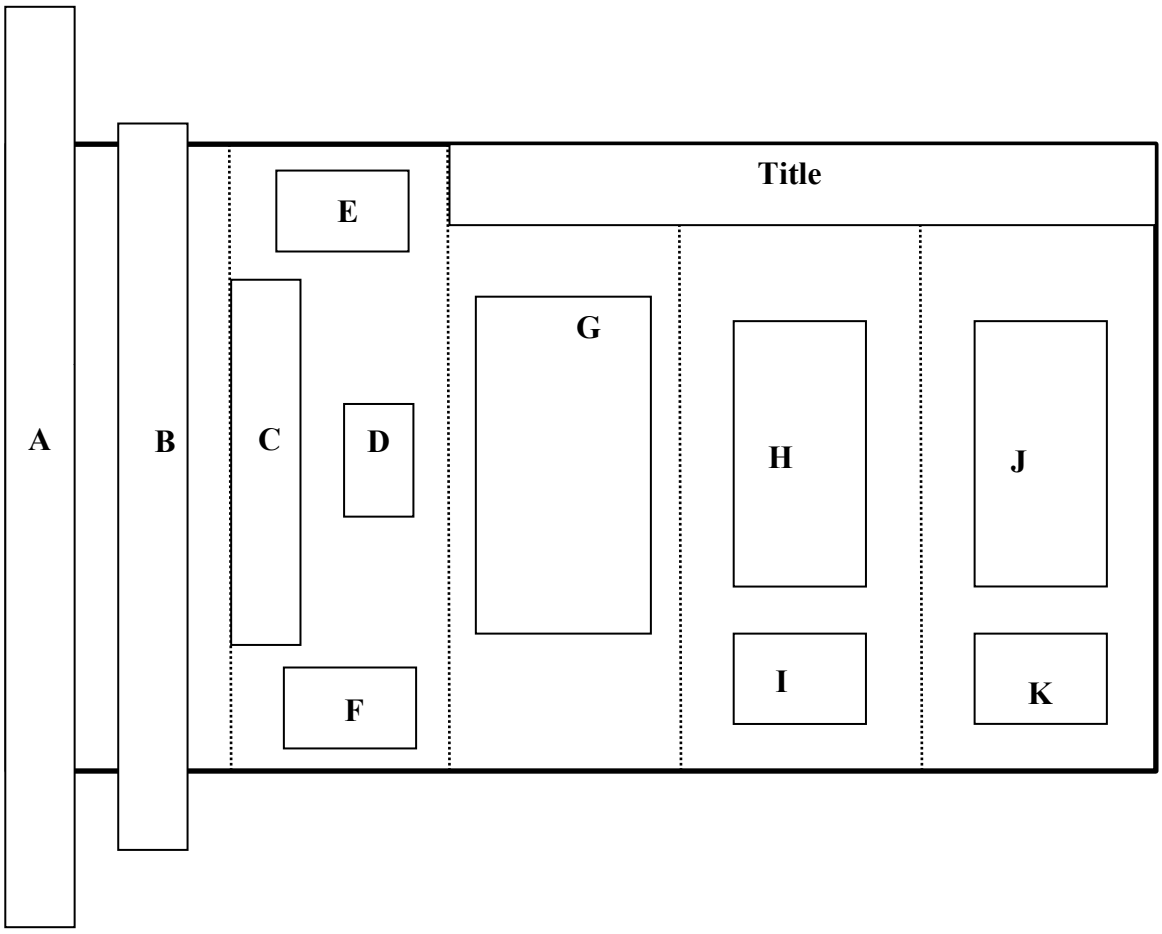

Figure 10. The layout of "A Prairie of Your Own" including all features.

Key: A-Indiangrass, B-Coneflower, C-Daylily, D-Kentucky bluegrass, E-Set one, F-Set two, G-Introductory text, H-Set three, I-Vendor list, J-Set four, K-Contact information.

western end. The near end of the exhibit will be set approximately eight feet from the door. It will be mounted on the wall so the bottom of the exhibit is 18 inches off the floor.

Figure 11. The layout of the barn is shown. Red represents the location of "A Prairie of Your Own," black represents the door, and yellow represents the sliding equipment doors.

Principles Used in Design

This exhibit used three of Medina's rules (2009). The memory, attention, and vision brain rules were used. The memory rule was incorporated by repeating certain phrases and ideas such as "Why Plant Prairie" in an effort to help the visitor form memories. The use of the attention rule resulted in a varied design. Not all of the visuals were pictures, some were preserved plants. One portion was interactive through a sliding panel. Only a short amount of time was needed to digest the messages. The vision rule led to the use of multiple graphics, visually stunning preserved specimens, and a limited amount of text.

Four of Beck and Cable's principles were also used (2011). References to yard work and the ideal of low maintenance landscaping were an attempt to follow the first principle and relate it to the life of the visitor. The call to action the exhibit focused on is intended to get the visitor to dig deeper and find more meaning in accordance with the second principle. The ninth principle influenced the limited text and influenced the selection of photographs. It also influenced the amount of white space in the layout. Not every square inch should be filled. The thirteenth principle was the inspiration for this exhibit, specifically the portion about encouraging resource preservation.

Conclusion

This exhibit, designed for installation on the western wall of the Barn at Indiangrass Hills, sought to motivate visitors to try native planting at home. It provided benefits of prairie plantings, information on planting, a list of vendors, and contact information for more details. It followed a five column layout. Medina's rules of attention, memory, and vision worked with the 1st, 2nd, 9th, and 13th principles of Beck and Cable.

Exhibit Two

Introduction

Exhibit two was intended to encourage visitors to pull garlic mustard at home or volunteer to do so at Indiangrass Hills. It provided visitors with natural history information and directions on how to remove garlic mustard. The design included a

narrative overview, the layout of the panel, information on the installation location, and the principles used in the design.

Overview

This exhibit was called "Not Your Grandmother's Garlic" and encouraged removal of the invasive species garlic mustard. It included a title, introductory text, natural history information, directions for removal, volunteer information, and a refillable dispenser that emits the scent of garlic mustard.

The introductory text read as follows.

> Garlic mustard began invading North America in the 1860's and has never stopped. In order to protect native woodlands, natural resource workers and volunteers spend time fighting this invader wherever it is found.

Two sets of a graphic and text provided natural history information. The first spoke to the reasons why garlic mustard is harmful to native woodlands. The second provided information on seed production.

The first set of natural history information included a picture of garlic mustard in its 2nd year. The caption for the picture simply said, "Garlic mustard." The text read as follows.

> Garlic mustard is harmful to native
> woodlands. It decreases the biodiversity
> of plants, insects, birds, and mammals.
> Garlic mustard doesn't play fair. It

even uses poison to kill the fungus

other plants depend on for life.

The second set of natural history information included a picture of garlic mustard flowers, seed pods, and seeds. The caption said, “From left to right, garlic mustard flowers, seed pods, and seeds. The text read as follows.

Garlic mustard spreads by seeds.

Each plant can produce hundreds

of seeds. The seeds can still

germinate after five years in ground.

Seeds are only produced by flowers

on plants that are two years old.

The directions for removal included background information and specific steps. Each step included a picture of that step. The text and directions were as follows.

Garlic mustard lives for two years. It makes seeds before the heat of summer and then it dies. Removing garlic mustard in its 2nd year stops seeds from spreading.

Step 1 – Find garlic mustard.

The picture with this step clearly showed what garlic mustard looks like.

Step 2 – Pull out garlic mustard roots and all.

The picture showed a garlic mustard plant freshly pulled from the ground.

Step 3 – Bag it up and carry it out. Plants pulled but left behind can still make seeds.

The picture showed a worker putting garlic mustard in a bag.

Step 4 – Burn it. Other means of disposal make leave seeds alive.

The picture showed garlic mustard being burned in a fire ring.

Information for volunteering for at a garlic mustard pull was displayed along with several pictures of smiling volunteers working together to clear an area of garlic mustard. The caption of the pictures read, "Volunteers pulling garlic mustard and making a difference." The text read as follows.

Indiangrass Hills needs volunteers
every spring and early summer to
help pull 2nd year garlic mustard
before it goes to seed. If you are
interesting please contact us.

The contact information followed in the same format as the other two exhibits.

The middle of the exhibit was home to text and refillable canister behind a circular mesh covering. The canister can be refilled once or twice a week with 1st or 2nd year plants, depending on the season. The plants will be cut to size and mashed a little. The text read as follows.

Why is it called garlic mustard?
Take a whiff and find out.

Layout

The layout for this exhibit was shown below in *Figure 12*. The exhibit will be four feet wide and six feet tall.

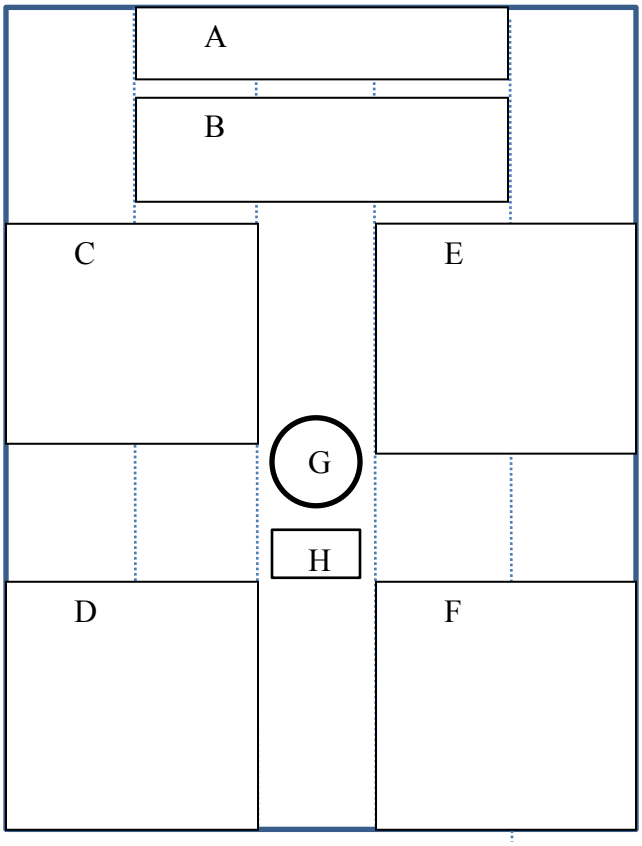

Figure 12. The layout of "Not Your Grandmother's Garlic" including all features. Key: A-Title, B-Introductory text, C-Natural history information one, D-Natural history information two, E-Removal directions, F-Volunteer information, G-Refillable scent canister, H-Text for canister.

Location

This exhibit will be located in the Barn at Indiangrass Hills. It will be located on the southern wall near the west end. The door is on the south end of the Barn on the western end. There is a sliding equipment door on the east end of that wall. The exhibit will be mounted on the wall between the two doors. The exhibit will be mounted on the wall so the bottom of the exhibit is 18 inches off the floor.

Figure 13. The layout of the barn is shown. Red represents the location of "Not Your Grandmother's Garlic," black represents the door, and yellow represents the sliding equipment doors.

Princicples Used in Design

Exhibit two used three of Medina's rules (2009). First, it made use of the sensory integration rule by using the strong and memorable odor of garlic mustard. Second, it used repetition of the fact that 2nd year plants make seeds to help form a memory. Lastly,

it used the vision trumps all rule by showing several pictures of garlic mustard instead of relying upon a written description.

Exhibit two leaned heavily on two of Beck and Cable's principles (2011). It used the first principle and the scent of garlic mustard to relate to the visitor. Does it remind them of food? Do they find it unpleasant? What scent in a past experience are they reminded of? It also used the thirteenth principle since it encourages resource protection.

Conclusion

This exhibit designed for the southern wall of the Barn at Indiangrass Hills sought to provide the visitor with knowledge about the plant and how to remove it. It provided natural history information, steps for removal, various pictures of the plant, and a scent producing canister. The exhibit followed a five column layout. Medina's rules of sensory integration, memory, and vision were used (2009). Beck and Cable's first and thirteenth principle were also featured (2011).

Exhibit Three

Introduction

Exhibit three provided a tour of various land management practice sites at Indiangrass Hills. It showed visitors the effect of management activities, past and present, while they gain experience with GPS navigation. The tour began at a small kiosk, then followed a trail. Along the way QR codes provided management and natural history information. Ideally, the location of the QR codes and the information accessed would

change with management activities. This design included four initial locations, the layout for each, and the principles used in design.

Overview

This exhibit has multiple features. A kiosk and several sites werelocated along a trail, part of which is a loop. A 1/10 mile section of trail runs from the kiosk location near the parking area to the intersection with a 3/4 mile loop trail. The trail surface is mowed grass. The elevation along the loop trail drops from the intersection to a creek and then climbs again back to the intersection.

This exhibit used technology to guide visitors around the site to gain knowledge on land management and natural history. A message on the website will inform visitors of the need to download a QR reader application and a geocaching application for their phones. The download of applications can be accomplished through the “app store” or similar feature on their smartphone. The website will also list the four geocache coordinates. On site, an introductory panel will offer similar information. The coordinates will be displayed in a locked, weatherproof display box attached to the introductory panel.

The introductory panel provided an introduction to the activity, mirrored the information on the website, showed a picture of a QR code post, and provided a weatherproof location for updates and announcements. The panel was in a small kiosk.

Figure 14. Graphic of kiosk style outdoor display. (from http://campton-parks-and-open-space.com/eagle-scouts/)

The text for the kiosk was as follows.

> Use a GPS, just like a land manager, to take a tour of various land management sites at Indiangrass Hills. Download a geocaching application and a QR reader from the "app store" on your device. Then enter the coordinates below in the geocaching app. Use the intro trail across the road to begin your adventure. Along the way use the geocaching app to find QR codes hidden in nature. Scan the codes to learn about land management activities in the area.

The four geocache locations shared several features. First, they will all be marked with three inch by three inch metal panels with a QR code printed on them. Second, the panels will be mounted on metal dual color seven foot posts. These posts are used on site to mark mowing hazards. Their height gets them above the tall grass. Their white tops help equipment operators spot them while in the field. The panel will be mounted on the post about 42 inches off the ground. Third, the locations will be in a loop. The loop will begin and end at the parking area. The placement of the geocaches will be near an established trail. However, visitors wishing to travel off trail will be able to traverse the prairie and woodland.

Each location will also be distinct in what it features. The QR code will link to a web-based PDF. The first site was near the intersection of the loop trail with the 1/10 mile access trail. The QR code accessed a PDF describing the use of the trail for management purposes. The document has a graphic and text. The graphic showed the use of a trail as a firebreak during a prescribed fire. The text read as follows.

Trails as Tools

Trails are an important tool
for prescribed fire. The trail
has been mowed and raked
to clear it of fuel for the fire.
The gap serves as a boundary
for fire known as a firebreak.

The second site was along the left, or northern, side of the loop at the bottom of the hill. The hill is a common spots for hand harvesting several kinds of prairie seed. The QR code for this site opened a PDF describing the process. The document has a graphic and text. The graphic showed a team of people on the slope harvesting seed by hand. Its caption read, "Harvesting prairie seed." The text read as follows.

Seeds are the Future

Each year, workers at Indiangrass Hills harvest prairie seeds for the future. After harvest, the seeds are dried and stored until planting.

The majority of seeds planted at Indiangrass Hills are harvested on site.

The third site featured a small grove of trees and shrubs. This site was formerly covered with invasive honeysuckle. The QR code accessed text and a graphic featuring a side by side comparison of before and after invasive removal. The caption read, "Before and after invasive honeysuckle was removed." The text read as follows.

Unwanted Invader

Honeysuckle was originally planted for its beauty and sweet smell. Sadly, the plant invades native space and crowds out desirable species. Unless

honeysuckle is removed, it will smother

oak saplings by blocking the sun.

The fourth site featured a recently burned prairie. The QR code accessed a graphic of a live fire during a prescribed burn and text. The caption of the graphic was, "Prescribed fire at Indiangrass Hills." The text read as follows.

The Ancient Tradition

Prairies are meant to burn. Historically,

naturally occurring fires would spread

across the land. Today resource managers

try to mimic nature's tradition. The activity

removes excess fuel from the landscape,

increases biodiversity, and recycles nutrients.

One strength of this exhibit was the adaptability of the locations. As management activities change locations the posts with the QR codes can easily be moved around. For example, the post and QR code originally at post four could be moved to a different burn unit. Additionally, new QR codes accessing information about other activities can easily be developed giving this exhibit the ability to describe any management activity that takes place within sight of the trail.

Layout

The layouts for this exhibit are shown below. Included are a diagram of what the three inch by three inch QR panels will look like (*Figure 15*), a layout for the 18 inch

wide by 36 inch tall informational panel at the kiosk (*Figure 16*), and a template for the PDFs accessed by the QR codes (*Figure 17*). The PDF graphics and text size were optimized for mobile format.

Figure15. An example of the QR code panel design for sites along the trail.

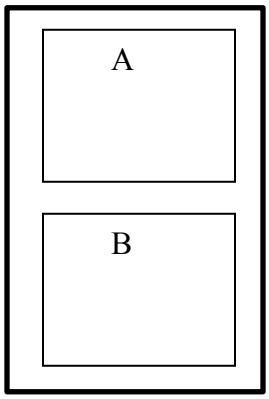

Figure 16. Layout of the kiosk in the parking area. Box A contained the directions for the activity. Box B was a weatherproof display box holding the current coordinates for the sites and other information about the trail including contact information, recent wildlife sightings, plants to watch for, and any special announcements like prescribed fire activity in the area.

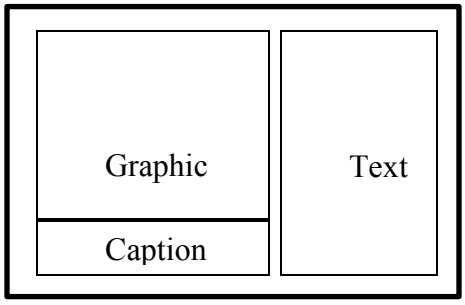

Figure 17. Template for all PDFs accessed by QR codes.

Location

This exhibit covered the largest area of any of the three. It consisted of an introductory panel and four satellite panels in the eastern sections of IGH. The introductory panel for this exhibit was located outside the barn near the parking area. The four satellite panels were located at interpretive sites showing varied land management techniques near a loop trail but also accessible off trail.

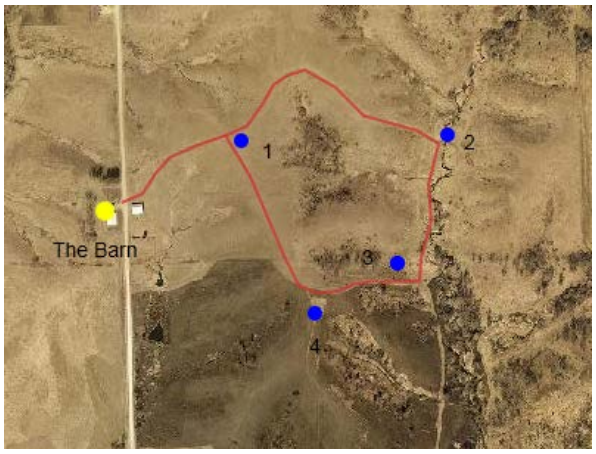

Figure 18. Map showing locations of satellite displays and trail used to locate them.

Principles Used in Design

The exhibit featured four of Medina's rules including exercise, sensory integration, vision, and exploration (2009). The hiking portion of this exhibit related it to the exercise rule. The scents, sensations, and sounds of prairie, stream, and woodland tapped into the sensory integration rule. The graphics in the PDFs and the naturally stimulating sights satisfied the vision rule. Lastly, the adventure of exploring somewhere new related to the exploration rule.

The exhibit prominently featured two of Beck and Cables principles (2011). The 7th principle spoke to the history of a place. The information provided by the QR codes can certainly do that. For example, the before and after pictures of invasive species removal provided a history of a site. The 8th principle concerns using technology with foresight and care. This document provided evidence of both.

Conclusion

Exhibit three incorporated smartphone technology and nature. The visitor used GPS technology on their smartphone to find sites at Indiangrass Hills. The sites contained a QR code which exposed the visitor to land management practices in use in the area. Four initial sites were designed, but the exhibit is adaptable enough to move current sites and add new ones.

Conclusion

This chapter laid out the design for three exhibits at Indiangrass Hills in Iowa County, Iowa. First, the shared graphic elements of the design were laid out. A color

scheme identified colors found in the prairie for use in design. Typefaces were identified for both the body text of exhibits and their titles. A column grid was identified to use for the layout. These three shared graphic elements provide a consistent look to the designs.

The first exhibit was designed to encourage native planting. Not every prairie needs to be hundreds of acres. The design included benefits of small prairie planting, options for planting, and a vendor list. The design also made use of preserved prairie plant specimens and powerful before and after graphics. The location for future installation was identified inside the Barn. Three of Medina's rules and four of Beck and Cable's principles were used in the design.

The second exhibit for in the Barn was designed to promote garlic mustard removal. Information was provided on how garlic mustard harms native woodlands, steps for removal, and contact information for future volunteer events. A special scent canister was added to the design to allow visitors a chance to smell this invasive plant. Three of Medina's rules and two of Beck and Cable's principle were used in the design.

Exhibit three was design differently than the other two. It was designed for outdoor installation with multiple sites. An introductory kiosk was designed to start visitors on their adventure. Four initial sites were designed to feature land management activities with the option to add more sites or move current sites as needed in the future. The design utilized four of Medina's rules and two of Beck and Cable's principles.

Chapter 5

Discussion

Introduction

This project created both tangible and intangible results. The tangible result is the design itself. The intangible results are more varied. The first intangible result is the process used to create the design. Theoretically, this process could be used at another location to design displays using research from brain based learning. Another intangible result would be the potential for future research. In this chapter, I intend to discuss these results and others through the lenses of lessons learned during the project, the next steps for the project, and future implications based on this project.

Lessons Learned

This project expanded my skill set. My professional experience, personal interests, and previous schooling have taught me the basics of interpretation, nature centers, and exhibits. This project allowed me to build upon those three aspects with literature and theory. I dove deeper into interpretive literature, stated a theoretical grounding, and explored brain based learning. I also learned how to let theory guide the design and the basics of design layout.

The various principles of interpretation put forth by Tilden (2009) and Beck and Cable (2011) are the foundation of interpretation. They guide naturalists, rangers, and

environmental educators on a daily basis. Likewise, these principles should inform the design of exhibits. Ideal exhibits would incorporate each principle in their design.

The theories of multiple intelligences (Gardner, 1987) and environmentally responsible behavior (Hines, Hngerford, & Tomera, 1986/87) grounded the project in theory while simultaneously guiding the basis for the design. The exhibits were designed with multiple intelligences in mind. For example, exhibit three uses the visual-spatial intelligence, the verbal-linguistic intelligence, and the bodily-kinesthetic intelligence throughout. The exhibits intentionally use part of the theory of environmentally responsible behavior by seeking to inform visitors on the knowledge of action strategies and the knowledge of issues.

Brain based learning should be used with everything we learn. However, neuroscience is a huge and complicated field, especially for those from another field of study. Medina's (2009) rules are a great starting point. Utilizing them in a deliberate manner should increase the chances of learning. Considering the breadth of the rules, it should be a straightforward, achievable task.

The application of the theories, principles, and rules stated above in the exhibit design was critical to the success of the project. The ease of said application varied depending upon the approach. The more challenging way to apply the literature was where each exhibit design began. One or two of the principles or rules would be selected to use as a starting point. These principles or rules would then be used to craft each aspect of the design. Some principles and rules, such as Medina's exercise rule, would easily

lend themselves to the design (2009). Others, such as Medina's stress or sleep rule, were outside the control of the design (2009). Trying to use rules and principles from that perspective to inform design was a lot like trying to put a square peg in a round hole.

A less challenging way to apply the literature came once the exhibit design was fairly complete. After using one or two of the principles or rules to initiate the design, it was fairly easy to watch for others to incorporate as the design moved forward. For example, the exhibit design itself might bring in something that appeals to another sense. A little careful, deliberate action can easily include the sensory integration rule into the design even though it was not the original rule or principle for that design.

The last way of integrating the literature with the design was the easiest. In fact, it didn't take any deliberate effort early in the design process. The very nature of these principles and rules lend themselves to exhibit design. They have a way of showing up in exhibit designs on their own. Therefore, once a design was complete it was common to identify another principle or rule that was present, regardless of any intent to actually include it. Medina's vision rule is a prime example of this (2009). It seems that as long as deliberate, thoughtful steps were taken when incorporating graphics into the design the vision rule would shine through. Based on the power of the vision rule, it seems that even unintended positive effects can occur with random or poorly planned visuals.

The very basics of design were also included in the scope of this project. However, graphic design of this level is a field onto itself, and a thorough examination of the principles that drive great design is beyond the scope of this project. Perhaps an

analogy to language would be appropriate. The project used a basic color scheme, a grid for layout, and deliberate typefaces. Those aspects of design could be thought of as basic vocabulary in a design language. It is important to keep in mind that there is a long way between basic vocabulary and a great work of literature. The way the elements are selected and the way the elements work together just are factors in separating good from great. For that reason, a basic layout and color scheme are included in the design. However, the final design and application of the selected elements are left to graphic design professionals in the employ of an exhibit fabrication company.

I also learned a great deal about project management from this experience. The extended time frame it has taken me to complete this project has added its own challenges. The most important aspect I've gained from this experience is the ability to break a large project down into small, more manageable pieces. In the end, all the little victories add up.

Next Steps

In order to go from a design on paper to an actual exhibit, there are several steps outside of the scope of this project that the site would have to complete. The first set of steps will be the completion of design, fabrication, and installation of the exhibits. Once the exhibits are in place, evaluations will need to be conducted in order to assess their effectiveness.

Before the exhibits can be fabricated, the final details of the design must be finalized. On-site photographs, contact information, and other final details must be

decided upon. Then a company should be selected to fabricate the exhibits. There are many companies both locally and nationally that are capable in exhibit construction. With the ease of internet commerce in our modern era, a simple Google search should provide multiple candidates to fabricate the exhibits. Important factors for making the selection include the estimated price and the presence of an in house design team capable of incorporating the text, graphics, color scheme, and other design elements into good looking exhibits. Ideally, multiple companies would submit an estimate and mock up for consideration. Once, a company is selected the fabrication can begin. The completed exhibits can be installed after delivery from the selected company.

The exhibits will need to be evaluated periodically after installation. An initial evaluation should take place after the exhibits have been installed for one year. This evaluation should focus on the effectiveness of the exhibits. Are exhibits functioning as designed? Are visitors learning what is intended by the exhibits? These are two examples of topics that could be explored by the first evaluation. A second evaluation should occur a few years after the installation. It should build on the knowledge of the first evaluation and dig deeper, asking questions about the application of theory and how it affects visitor learning.

Implications

This project could have lasting effects on exhibit design. While it is not the first exhibit design ever to draw on research from outside of the field, the use of brain based learning research holds tremendous potential for future exhibit designs. That potential can

increase in the future, especially if new research shows designs utilizing brain based research are more effective than other designs.

The use of brain based learning research in exhibit design could change the way exhibits are designed. If future research demonstrates the efficacy of this technique, using brain based learning research in exhibit design could become a standard practice. In a world where exhibits are designed to stimulate the brain, nature centers could become much more successful at teaching their visitors important lessons about conservation, preservation, and nature. Ultimately, that could result in more informed and environmentally responsible citizens. Now is the time to begin research on the effect of brain based learning on the efficacy of exhibit design.

Conclusion

This project has produced a set of steps for exhibit design, contributed professionally to research based exhibit design, and met challenges along the way. The results of those activities are the tangible and intangible products mentioned at the beginning of the chapter.

The steps for exhibit design used during this project included identifying research literature on exhibit design, identifying a site and its characteristics, and laying out exhibit designs based on both sound theory and site specifics. First, research was identified from both inside and outside the field of interpretation. Information on interpretive principles, interpretive design, and the foundation of interpretation came from within the field. Information from outside the field came from multiple places, most

notably psychology and neuroscience. Second, the site was identified as a tallgrass prairie in east central Iowa. They have a medium sized building and 752 acres of prairie and woodland. Their focus is on citizen and private landowner based natural resource restoration. Last, the exhibits were designed based on the first two steps. The research informed how the exhibits were designed, specifically with brain based research in mind. The site specifics indicated what the content would be. The exhibit designs represent the intersection of research and site specifics.

The professional contributions of this project have both local and widespread effects. The local professional contribution is the exhibit design. Once implemented, it will fill the need for new and research based exhibits at the site. On a more widespread scale, this project made a professional contribution by laying out a series of steps to design exhibits with regard to brain based learning. In the future, that contribution could become greater if future research validates the efficacy of such exhibits.

This project came up against several challenges. It overcame them all. The building at the site provided most of the challenges. First, it is a medium sized building. This was challenging because it limited the size and number of exhibits. Another challenge was caused by the building is its multiuse nature. The other needs of the building limited where exhibits could be located and how they could be attached or mounted in place. The final exhibit design took these challenges and others into consideration to produce what is hoped to be a sound plan for effective exhibits in a small interpretive center.

The process of exhibit design used in this project could be applied at other nature centers. Each design process could present its own challenges; however, the process itself would remain the same.

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