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Integrating Science at a History Museum

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Embarking on an interdisciplinary activity or exhibition in a museum creates something new by crossing boundaries. Combining science and history not only allows each discipline to complement the other, it also encourages multiple modes of learning. While interdisciplinarity can present challenges—like finding the right balance of science and history—this approach enhances visitor experience in fresh and exciting ways. This technical leaflet charts the development of an exhibition that combines science museum activities with historical stories, objects, and settings, offering history museums a possible road map to effectively introduce science, technology, engineering, and math (STEM) into their institutions.

For the past decade, Conner Prairie, in Fishers, Indiana, has created experiences that help visitors learn about science in historic environments. Across our grounds, visitors can experience historical activities that demonstrate science concepts, like churning butter or shaping iron in a forge. Expanding this idea beyond our historic areas, Conner Prairie staff sought to create an exhibition that featured not just the history of science, but the active processes of the scientific method embedded in historic stories. We partnered with the Science Museum of Minnesota and received funding from the Institute of Museum and Library Services and the National Science Foundation to create a new kind of exhibition built on best practices from history and science museums.

The *Create.Connect* exhibition developed through a series of different iterations. As we treaded new ground, we wanted to be sure our final experience would be rich in both history and STEM learning, and the iterative approach allowed us to find the right balance between the two disciplines.

Today *Create.Connect* is an indoor visitor experience that integrates historical narratives with make-and-test activities that demonstrate STEM concepts. The experience offers four nodes, each with a different setting and story: a 1936 kitchen, a 1910 aviatrix's workshop, a 1900 windmill sales booth at a fair, and a 1958 patent office. Live interpreters—both costumed historical characters and modern day uniformed staff—facilitate each space and invite visitors to interact with the activities, with the goal of fostering the kind of play that mirrors the scientific method and the design process.

We present *Create.Connect* as an example because the structure of the exhibition works well either as a whole or in parts. The exhibition contained different nodes, and each of the nodes could work independently as a smaller, but complete, visitor experience. Organizations can scale their own projects up and down based on resources.

Staying true to your mission

One obvious challenge to incorporating two seemingly disparate disciplines is the perception of your visitors and other important stakeholders. If the mission of your site is history-based, some might question the incorporation of scientific content as "mission creep" or "chasing STEM dollars." Education of all stakeholders, therefore, is an essential part of the project plan. In the conceptual stage, the project team was mindful that some board members and staff were unconvinced. Fortunately, we had planned the exhibition so that it developed step by step, with formative and remedial evaluation of visitor perceptions built into the project timeline. In evaluations, we found that 99 percent of visitors believed that *Create.Connect* fit at Conner Prairie. It quickly became clear that visitors by and large experienced no dissonance at finding science in a history museum, and this finding spoke to other stakeholders.

Expand your abilities with the right partner

The process of developing the exhibition and interpretation began a year and a half before opening. The staff of Conner Prairie and the Science Museum of Minnesota brought the content and methods of their disciplines to the table. Conner Prairie gained the insights and experience of our partner museum staff with tried-and-true science activities to utilize in this experience. Avoiding the need to develop new science activities allowed the project to jump ahead several steps right away. The Conner Prairie team shared their expertise in telling engaging stories from the past and offering immersive settings that encourage exploration of history, as well as our unique approaches to first-person interpretation and the use of historical objects. Partnerships can be a very effective way to grow your institutional capacities.

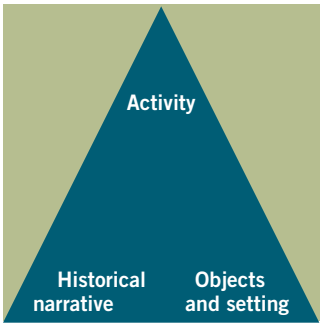
Planning Your Experience

Once you have laid the groundwork for your project by talking with stakeholders and potential partners, you can begin the conceptual planning phase of your experience.

The *Create.Connect* framework

From the initial development of *Create.Connect*, we created an interdisciplinary framework that combines setting, activity, and historical narrative. We strived to seamlessly integrate each component into the visitor experience, so that no one element was stronger than the others.

Setting is the physical environment you create for your experience, including historically immersive spaces as well as historical objects. *Activity* refers to the hands-on activities that will demonstrate STEM concepts, the scientific method, or design processes while also relating to the historical narrative. The third component of this framework, *narrative*, is the historical story you tell and the way you tell it—through text and images, audiovisual presentation, or historical characters and live interpretation.



Where should I start? The genesis of *Create.Connect's* nodes

Your conceptual planning will likely begin with some kind of "inspiration." Perhaps your community has a prominent STEM story, or maybe you have a great item in your collection related to STEM. In the development of *Create.Connect*, each of our nodes grew from a different point of inspiration. Planning for the "Electricity" node was driven by Conner Prairie staff familiarity with the Rural Electrification Administration, the New Deal program of the 1930s that revolutionized life in rural Indiana by bringing electricity to home and farm. It was a pivotal program in the lives of rural Hoosiers, and one that some still remember for how greatly it improved their quality of life. We knew that stories with an obvious turning point—a moment when technology or people's lives changed significantly—resonate with visitors. The story of the Rural Electrification Administration provided the

STEM connection to electricity. The other elements—the setting and an activity—grew from the story.

Conversely, the "Windmill" node generated from a large Flint & Walling Star windmill that was part of Conner Prairie's collection. This fascinating object, made in Indiana, had innovative features that made it famous around the world. It provided an opportunity to talk about a historic Indiana company, explore how windmill mechanisms function, and show how wind can do work. In this node, the activities and historic narrative followed from the object.

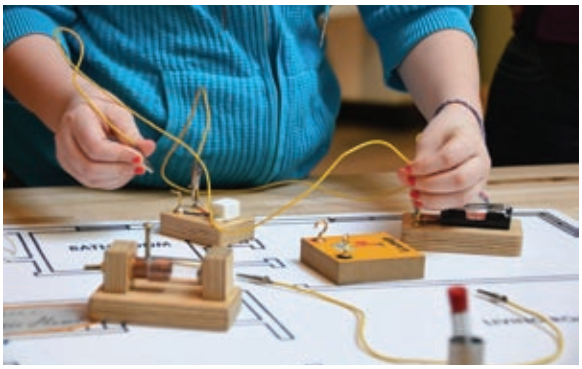
In a third node, the genesis was a popular activity from the Science Museum of Minnesota that uses ramps and levers to create complex chain-reaction machines. Through research, we found that Purdue University has for decades been holding a Rube Goldberg machine competition for its engineering students. We thought this interesting story tied well to the activity; however, during prototyping we found that many visitors came away from the experience thinking Rube Goldberg was from Indiana or otherwise misinterpreting the connection. At the same time, the activity had some of the highest stay times in *Create.Connect*. So the historic narrative shifted to one focused on Indiana inventions and the process of patenting an invention. The historical setting of a patent office in Indianapolis provided a place to create and to patent complex chain-reaction machines. We chose to set this node in 1958, a time when our nation's attention was turned to STEM education after the launch of *Sputnik* by the Soviet Union. The new historical narrative also generated numerous ideas for authentic and reproduction objects to augment the story.

The fourth and final node presented opportunities to look to character for inspiration. The exhibition team struggled to find a suitable narrative or object that connected to early aviation. There was not one story, but a plethora of Indiana aviation vignettes that came together. We narrowed our focus by creating the character of a 1910 aviatrix, a young woman determined to design and build a better airplane. This historically based composite character enabled us to incorporate a female voice, and the narrative we crafted led to choices for activities and for the setting—her workshop, complete with historically appropriate objects.

Creating Your Experience

Bringing together story, objects, and activity

Once you have the inspiration for your project—whether beginning with story, object, or activity—it is time to flesh out the rest of the complementary elements of the experience. We found that these STEM and history experiences work best when the three parts of the triangle—object, story and activity—are closely aligned and visitors can easily see the conceptual connections between them. Through prototyping, we found a number of strategies that can help tie all the pieces of your experience together.



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This circuit-making activity was changed to incorporate the historical narrative.

- **Bring history into the activity.** Visitors will likely spend a large amount of time at your activities. This presents an opportunity to put the history front and center by incorporating it into your activity. Our first version of the circuit block activity in the "Electricity" node used batteries, wires, and electrical elements like LEDs and fans attached to wooden blocks to make circuits. Wanting to make the history more visible in the activity area, we redesigned the blocks to represent appliances, which visitors would then place in the floor plan of a home. Now, while visitors are practicing circuits, we can talk about how families at that time planned the wiring of their own houses.
- **Show STEM in the objects.** Museums can engage people with objects by inviting visitors to think about how the artifacts work or the ways they demonstrate STEM principles. For instance, in our "Windmill" node we display a second Flint & Walling star windmill mechanism (without the blades) on the floor. Visitors can see its workings up close and move the parts themselves, which has proven to be an effective way to demonstrate how windmills work along with engineering principles, like how to translate circular motion into linear motion.
- **Avoid making false connections.** In our "Windmill" node, we started with a hands-on activity focused on electrical turbines. Visitors used wood and cardboard to make miniature turbines to test and see if they would generate electricity. However, staff found it difficult to guide visitors, especially children, through the conceptual steps to understand how what they had built related to the star windmill, which does not produce electricity. Our partners at the Science Museum of Minnesota worked with us to create an activity that demonstrates the physical work that windmills do. Now, the activity demonstrates the same concept as the historical object.

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The Patent Office node uses design elements like the door, window, and floor treatment rather than walls to create a space.

- **Use the setting to foster connections.** We found that making an immersive setting in which to house the activity and objects helps connect activity and story. Setting can help give the activity a reason to exist and feel less disjointed. At the airplane activity, visitors are not just making airplanes out of paper and straws; they are creating aviation models to test new designs.

The word "immersion" can be a high standard. Most of the nodes in *Create.Connect* are delineated by a modular wall system, but are open to the rest of the exhibition. They need not be immersive in the same way houses are in our 1836 historical village, for example. By displaying historical objects as they would have appeared in use (like placing an authentic radio on a side table instead of a vitrine) and using simple design elements like lighting, wall treatments, or windows creatively, museums can effectively communicate setting without building a fully immersive environment. Our 1950s patent office does not have a wall system, and uses a stand-alone door and window to theatrically suggest and evoke an enclosed space without the need for walls.

Components of an interdisciplinary node

We use a number of exhibition elements to create the historical setting and foster exploration of history and STEM. Each of our nodes contains at least one of the following components; depending on the scale of your project, you could select just a few of these to help create a complete and cohesive experience.

- physical setting (wall set, paint, furniture) to emphasize time period
- activity table for making and testing
- other interactives that demonstrate STEM concepts
- historical objects (authentic or reproduction), as accessible as you are comfortable with
- introductory label copy to orient visitors to the setting
- "snoops" (hands-on, explorable exhibit elements or objects), such as patent copies in drawers or historical tools hidden in an "aviatrix's cabinet"
- period-appropriate audiovisual media that interpret the historical narratives being told
- loose materials—such as reproductions of primary sources, books, or magazines—to invite in-depth exploration and enhance the setting
- integrated labels scattered throughout the setting, to invite exploration of the historical story
- a mix of objects, labels, and activities that target different styles of learners

Case Study: The "Electricity" node in *Create.Connect*

Setting: This node resembles a 1936 farm kitchen in rural Indiana that has just received electricity. Installed in the modular wall system are two windows, complete with curtains, one of which shows historical and modern images of rural Indiana via a digital video screen. The walls are white and green and decorated with a chair rail. In one corner, a calendar shows the date. Visitors can open this calendar to reveal more information about the Rural Electrification Administration, the New Deal program that brought electricity to Indiana farms. An actual 1930s-era stove invites hands-on exploration with its many doors and compartments. Opening these, visitors find coal and replica food as well as short-form labels describing the importance of coal stoves like this one. Near the stove, a single bare Edison-style bulb hangs from the ceiling, and a heavy pre-electric iron demonstrates how difficult this simple chore was before electricity. In the center of the room, an actual radio from this era has been re-engineered to play digital content such as music or a radio program on rural electrification that we created. The node also features an authentic Hoosier cabinet and refrigerator which, like the stove, are filled with authentic and replica items from the historical period as well as short labels that share more about farm life after the advent of electricity.

Activities. This node features two activities: a make-and-test activity table and an experiment bench. At the activity table, visitors encounter an array of electrical elements and a variety of switches. Using these, along with clip-on wires and battery packs, visitors try to make working circuits that can power an element like a light. The wooden blocks that hold the electrical elements are printed to look like household appliances—for example, a red LED represents an iron. Once visitors have created, through a process of trial and error, a working circuit, they can place that appliance in a floorplan of a house, just as families in rural Indiana in the 1930s had to plan their own household wiring. The experiment bench also presents a variety of other electrical components, but these snap together with magnets. Here, visitors are experimenting with AC and DC power. By following instructions on a computer screen, they can complete

Ways To Find STEM Hands-On Activities

As we mentioned above, partnering with an institution that has expertise in creating hands-on STEM activities is invaluable. Contact a science center or children's museum near you to see if staff there would be willing to partner or consult with you. However, as we described above, these activities work best in a history-and-science experience when they are wrapped in historical context.

There are numerous publications available that have ideas for STEM activities. Many use common materials that require only a small budget. These may be much less durable than museum activities and might require supervision, but they can be fun hands-on demonstrations of STEM concepts. The Exploratorium has published a series of "cookbooks" for constructing science exhibits. They also offer a science "snackbook" focused on smaller-scale exhibits and activities that use everyday materials.

- Bruman, Raymond. *Exploratorium Cookbook I: A Construction Manual for Exploratorium Exhibits.* San Francisco: The Exploratorium, 1987.
- Doherty, Paul and Don Rathjen. *The Exploratorium Science Snackbook.* San Francisco: The Exploratorium, 1991.
- Hipschman, Ron. *Exploratorium Cookbook II: A Construction Manual for Exploratorium Exhibits.* San Francisco: The Exploratorium, 1990.
- ———. *Exploratorium Cookbook III: A Construction Manual for Exploratorium Exhibits.* San Francisco: The Exploratorium, 1993.

a variety of experiments that demonstrate the properties of alternating current and direct current. An oscilloscope makes the electrical flow "visible" and is an introduction into this real-world STEM tool.

Character. Each of the four nodes is inhabited by a character, a first-person interpreter playing a fictionalized role as a person from the past. Here, visitors can meet Vera Zimmerman, a homemaker and farm wife who has just received electricity for the first time. She is excited about how this new technology is going to change her family's life and eager to learn more about how electricity works. She has been given some materials and information from the Rural Electrification Administration to help her family start planning for electricity, and she enjoys sharing this information in conversations with the visitors in her home. She understands how energy flows through wires and how to wire your home so the electricity runs in a circle, so she is an able teacher to those learning to make circuits. Above all, she is thrilled to chat about the positive changes to her family's life since they received electricity.

Live Interpretation

While live interpretation is our primary interpretive method at Conner Prairie, we know that many museums lack the staff resources to offer this kind of experience. Still, we feel it is an important component of this project and would urge you to consider offering facilitation by paid employees or volunteers at least part of the time.

Styles of interpretation

Create.Connect is staffed daily by two kinds of interpreters: costumed historical interpreters and modern uniformed interpreters. Costumed historical interpreters are in character as a person from one of the four time periods represented in the exhibition, giving them a home base if you will, but with the ability to step beyond it. In their home node, the characters converse with visitors about their unique perspective on the pivotal scientific story of their time and how it impacted their lives. These interpreters put visitors into roles as people from that particular era (*Isn't it exciting to finally be getting electricity?*) and offer the science activity as part of the historical story (*The electrification man brought these blocks for us to figure out how to make an electric circuit. Want to try?*). Modern interpreters in uniform blue shirts do not adopt a role, but engage visitors with the story from a third-person perspective (*What is the first thing you'd buy if you just got electricty?*) and invite visitors to the STEM activity *(Can you figure out different ways to build an electric circuit?)*. The historic characters can move into nodes other than their home base, and in these they interact with visitors more from a third-person perspective. We were surprised at how willing our visitors have been to transition freely between time periods.

In the other aspect of Conner Prairie's interpretation, we ask visitors questions in order to guide them to participate in historical thinking and the scientific method. For example, in the "Windmill" node, interpreters ask visitors to think of what wind power could do for them (with some movable mechanical options) and invite them to build a better windmill at the activity table. Our historic characters generally offer visitors a challenge set in that time, such as building a better designed windmill.

Training your staff

Conner Prairie interpreters are trained to spark conversations with visitors, to find out what they

Making History Hands-On and Finding Balance

In our initial evaluation of the *Create. Connect* prototype, we found that far fewer visitors stopped at elements of the historical setting than at the STEM activities. This was an ongoing concern in creating an interdisciplinary experience. We felt that by making the historical elements of the exhibition more hands-on, visitors might be inclined to interact with them more. This is how we set about adding more interactive historic elements for our "Electricity" node.

Our collections team took authentic appliances from the 1930s and stabilized them to allow our visitors to interact with them in a hands-on way. We also attached labels to the objects using magnets, to help visitors make connections between the objects, the historical narrative, and STEM principles discussed. In subsequent evaluation, we discovered that more people visited these objects than had visited the static labels and images.

If you have objects that are too fragile to be left out but will not be damaged by touch, consider offering staff-guided touch experiences to your visitors. Staff can share the interesting features of the object while supervising their exploration. Of course, reproductions are an option, but visitors are always fascinated by opportunities to touch the "real" thing.

Reproductions of print resources can be an effective way to show the past. *Scientific American* magazine has been in print since 1845, and older issues are available free online. Articles from your time period, printed and bound with a reproduction of the magazine's cover for visitors to peruse, can illustrate how people were thinking about science in the past while adding to your historical setting. Other historical print materials can serve a similar purpose; in our "Windmill" node, we have reprinted a catalog from the Flint & Walling windmill manufacturers. As always, when making print reproductions, staff must be mindful of copyrights and how they are applying fair use guidelines.

might be interested in exploring, and to offer provocative questions and challenges. Conner Prairie's "Opening Doors" method starts with the idea that each guest brings his or her unique experience to the museum, and the interpreter meets guests where they are. Throughout the site, we invite visitors to take part in any number of activities, which might be historic, scientific, or both. *Create.Connect*—although more concentrated, with two disciplines and four eras in one exhibition—is essentially the same.

At first, interpreters assumed they needed to know all about the science behind each node. However, understanding and communicating all the facts about a science topic is not the goal of the experience. They should be able to explain what is happening in the activity, but it is more important that they encourage visitors to experiment, solve problems, persist through frustration, and discover things on their own than communicate large amounts of STEM content.

Formative Evaluation

In the development of *Create.Connect*, the project team used formative evaluation to guide our work. Formative evaluation offers feedback on the experience before it is finalized and thus provides useful information to the project team about what works, what doesn't, and what needs to be changed. If you choose to use formative evaluation, be sure to leave room in your production schedule and budget to adjust the experience based on what you find. Find out from potential funders if they will support formative evaluation, a prototyping phase, or a line item for possible remediation of the experience.

Museums can generally do formative evaluation themselves, even if they do not have a dedicated evaluator on staff. However, if you want or need to carry out a summative (final) evaluation of your experience, you would typically partner with an outside evaluation firm or independent evaluator.

What should I evaluate?

Articulating clear goals or evaluation questions is an important part of assessing success in your experience. Here are dimensions of success to consider.

- **Does this experience fit at this institution?** Will your visitors feel that this experience is out of place in your institution? Will this new experience align with your institution's "identity?" It is important to consider that the way you see your museum may not be the same as the way your visitors see it. A good place to start is simply asking your visitors, "Does this fit in or belong here at [our institution]?"
- **Do visitors perceive the experience as containing both STEM and history?** Striking a balance between

history and STEM in your experience is essential; one should not take clear precedence over the other. In an interview, you could ask visitors to describe their interdisciplinary experience. Some people may describe the experience in only STEM terms or only history terms, but when you view the data overall, you should be able to see that both history and STEM thinking are represented in visitors' words.

- **What are visitors doing in the experience?** Imagine what a successful interaction at your STEM activity would look like. Do people spend a long time working on their projects? Do they work together with other people in their group? Do they ask questions about what they are doing? List the behaviors you would like to see and observe your activity to see if they are happening. For example, we were interested in the behavior of "iterating," or trying multiple solutions to solve a problem.

What method should I use?

Surveys: Surveys are a simple way to gather a large number of responses relatively quickly. They are effective for gathering visitor reactions to the experience and provide data that are typically easy to analyze.

Interviews: Face-to-face interviews with visitors are best when you are asking more complicated questions or when you want to dig deeper into visitors' responses by asking probing questions like, "Tell me more about that" or "Why do you feel that way?" In the evaluation of *Create.Connect*, we combined the survey and interview methods. Data collectors gave visitors a survey to complete and afterwards asked them to explain or expand on their responses in an interview.

Observations: You may want your experience to prompt certain behaviors in your visitors, like collaborating, trying something more than once, or being successful at an activity. Data collectors can observe a single activity or an individual person and note the target behaviors that they exhibit. Data collectors can also identify some demographic characteristics like the perceived age and gender of the person observed and what kind of group they are visiting with (a family, all adults, a school group, etc.).

Timing and tracking: A timing and tracking study can show if visitors are staying long enough to engage with the ideas presented in your experience. This method will also show if there are activities that are more or less attractive than others. If areas show low numbers of visitors stopping or very short stay times, the project team can make adjustments to facilitate visitor engagement in that area. In the evaluation of *Create.Connect*, we combined the timing and tracking and observation protocols; a data collector tracked and timed a visitor and also noted instances of target behaviors when that visitor stopped at an exhibit element.

Recording conversations: For more in-depth analysis, we recorded thirty-five families' visits to *Create.Connect*.

Something is not working; what should I do?

Formative evaluation seeks aspects of the experience that are not performing to expectations, so you can improve them. If you discover something isn't working at this phase of the project, that's actually a positive thing, as you now have the time and budget to fix it. It may be important to express to your leadership or funders that problems at this phase, and the subsequent adjustments, are not evidence of failure. Rather, you had planned for prototyping and remediation from the beginning to allow this experience to meet the needs of your audience most effectively. If

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A costumed interpreter guides guests in their exploration of a replica Edison bulb.

Blending History and Science in Live Interpretation

Fostering historical and scientific thinking simultaneously can be an interpretive challenge. Structuring the science into the narrative helps. Here are a few techniques that worked very well for us.

Role play: Try working in costume and place the visitor into a role when they come into the space. Engaging visitors' imaginations in another time and space creates an emotional component that can add to fun and the learning potential.

Object work: Try putting objects into the hands of our visitors, encouraging them to handle everything in the space. People experience the world tactilely, and handling an object makes the experiment we're doing more real.

Layering: Our interpreters are trained to engage guests in conversations that guide them to understand how STEM and history are interrelated, particularly within the context of the historical story being told.

The final iteration of our windmill activity was shaped by prototyping and testing.

you find that something in your experience is not successful, you can do a few things to help generate ideas for how to mitigate the problem.

Read research on the topic: Research has been carried out on a number of topics that might relate to your experience, like gender balance in STEM activities or fostering collaboration. If you find visitors are not doing what you hoped they would do, see if anyone has published research on how to foster the behaviors you want to see.

Try rapid prototyping: Sometimes you may not be sure how to address a problem, but you don't have the budget to produce multiple versions of exhibit elements. You can always mock up new labels or activities using inexpensive materials and observe visitors using them to see if your changes are successful. For instance, we created instructions to use in observations by printing images on a standard color printer and attaching them to a foam core board. Interpretation methods can also be adjusted rapidly, and facilitators can give immediate feedback on the impact of different strategies.

Look at what other institutions have done: Bring the issue up to a listserv or similar forum. Often, someone else will have encountered the same problem before. Other types of museums, like children's museums or science centers, will have experience with these types of hands-on activities and know what they require.

After you have made a significant change, you will want to collect the same kind of data you collected before, to see if your changes are having any effect on the issue.

Conclusion

Blending STEM with history at your institution can enhance the visitor experience by helping visitors make connections between these disciplines. The exhibition at Conner Prairie provides an unambiguously historical experience, while also offering opportunities for the kinds of deep hands-on engagement that families and school groups love. You will probably find, as we did, that your visitors aren't solely focused on history—they are curious about and interested in many subjects and topics. They are not troubled by the integration of science. That being said, it is important to approach a project like this thoughtfully and always with the goal of aligning the STEM experience with your overall mission and interpretive style. Taking it step by step and checking in with your audiences along the way will help you determine if you are on the right track. Hopefully, your careful planning can result in an enjoyable and interesting experience that is rich in both history and STEM learning.

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