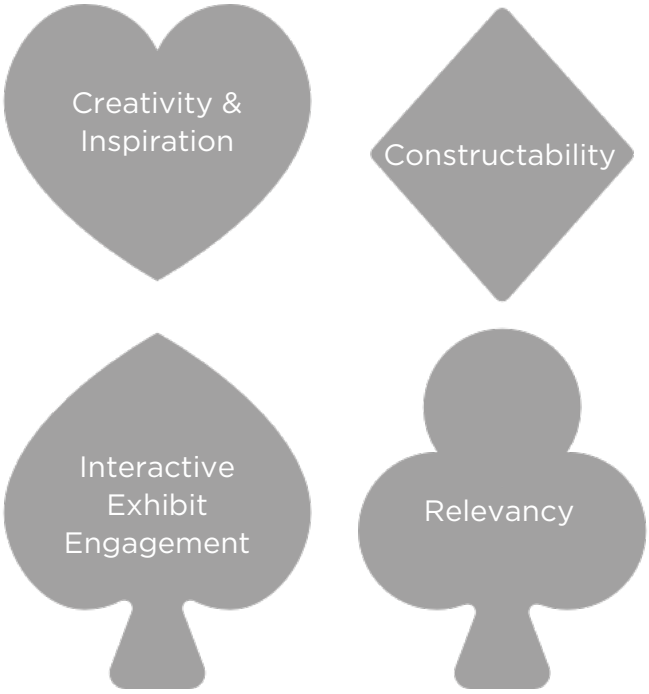
BURNS McDONNELL

BATTLE OF THE BRAINS

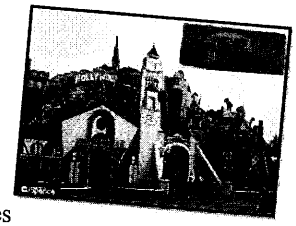
JUDGING THE BIG IDEA

You be the judge!*

1. Select a partner and a playing card.
2. Your team will receive a proposal to read. Determine if the proposal follows the requirements of:
    - ❑ No more than four pages in length (preferably with one-inch margins and font size no smaller than 10 points)
    - ❑ Diagrams/sketches of the exhibit are present
    - ❑ Rubric sections are all present (preferably in rubric order)
3. Find the section corresponding to your playing card.
4. Use the rubric to evaluate each criterion in your assigned section. Circle the best description of each criterion based on your proposal and assign a score for that section.
5. Add your team results to the other teams who are reviewing the same proposal. Would this be a competitive proposal? Why or why not?



*Since the competition debuted in 2011, we've seen hundreds of great proposals filled with big ideas, STEM principles and amazing student enthusiasm. Sample proposals are provided as representative examples, but please note that the competition rubric changes from year to year, so what you see in these proposals from past competitions may not match the requirements of the current competition.



Welcome to DenCITY!

Section 1: Creativity and Inspiration

Section 1.1 – DenCITY Tourism Bureau Announcement (Main Idea)

"Welcome to DenCITY! Our bustling metropolis is packed with engaging, memorable experiences that introduce visiting tourists to the concept of density and invite them to explore how density impacts everyday life through its many attractions. The cartoonish theme and bright colors of DenCITY are perfect to draw in and energize guests of all ages, but do not let that make you think the city lacks substance. In fact, DenCITY is off the charts in awesome exhibits (mass) per square foot (volume). Come visit today!"

Section 1.2 – STEM Principles and Concepts

Though density may initially seem like a simple topic, it is actually quite, well…dense! Through the single organizing theme of density, we can explore mass, volume, weight, properties of engineering materials, fluid dynamics, and much more. The following describes how DenCITY will teach STEM principles and concepts to its guests.

Science – The idea of density is central to the understanding of much of our physical world and the sciences that seek to explore and explain that world. From the movement of air and formation of weather to the different layers of Earth, density plays a vital role in supporting numerous scientific specialties.

Technology – Many of the most impactful technological advances in recent years have relied upon a strong understanding of a material's density and how that density will impact a given technology's performance. For example, automobiles, airplanes and even cell phones!

Engineering – Whether they are designing a building, a plane, an electric toothbrush, or anything else, density is a critical consideration in every material selection decision made by engineers. Balancing the mass of an object against the volume of space it takes up is an essential task in maximizing that object's value and performance. Combining those considerations with additional properties like conductivity, malleability, and others allow engineers to continually deliver bigger, faster, smarter, safer products.

Mathematics – Though the concept of density can be described qualitatively, in practice it is inherently a quantitative measure. To utilize the concept of density in support of science, technology, and engineering, we must use mathematics to measure and calculate the very precise values of density for substances.

Section 1.3 – Inspiration

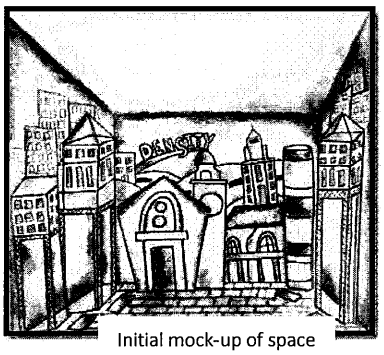
We drew inspiration from outside sources in three main areas: our topic, our approach, and our theme.

Topic (Density) –
After visiting Science City, ourselves, we noted that many of the exhibits that were successful across all age groups were very simple, straightforward, and approachable with optional layers added of complexity for those who want it. Good examples of this include the simple machine playground outside and the properties of water exhibit. Both exhibits can be immediately interacted with and enjoyed by younger participants while having interesting scientific explanations for older participants.

We felt that the topic of density has the same potential to provide highly engaging and highly visual exhibits that will appeal to all ages while also providing some amazing supporting science and application for the more mature guests.

Approach (Cohesive) –
Our class's favorite exhibit at Science City was the Mr. E Hotel. After discussing this as a group, we decided that what made that exhibit stand out was its ability to combine its content (visual illusions) into a single, continuously themed experience. Rather than have a collection of separate elements that each look at the same central topic, that exhibit made it feel like all the elements contributed to the larger and more cohesive whole that was the hotel. We wanted to replicate that.

This led us to the idea of "DenCITY," an exhibit that feels like a separate place from the rest of Science City. In the city, there will be many unique experiences that will allow guests to explore different aspects of density, but we intend for it all to feel very complimentary with the elements building and adding to one another. This helped us



Initial mock-up of space

design the layout for our exhibit as a hollow structure with a city-like scenery in which each of our elements will have its place.

Theme (Cartoon-like) –
Our class realized that real cities may feel too cold, stark, or imposing to create the type of environment we wanted, the kind that would foster curiousness and creativity. Drawing from an old ride called the Superstar Limo at Disneyland Resort in Anaheim California, we became very interested in creating a cartoon-like appearance for DenCITY. Ideally, that theme will make the city appealing and inviting to younger guests, softening what can be complex content.

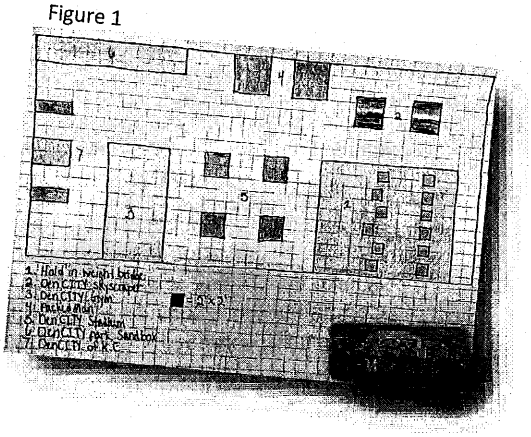
Additional visual inspiration was drawn from different city themed playgrounds around the world, including this skyscraper inspired equipment from a playground in New York City and Science City itself!

Section 1.4 – Discarded Ideas

Most of us enjoyed all the ideas for exhibits we had, but some of them just didn't make the cut. These included:

1. Scientific Putt-Putt – fun idea but not especially educational
2. Plants – a lot of potential, but our ideas were very disjointed
3. Density Hamster Wheel – we had safety concerns
4. Density Dunk Tank – collectively the class was not passionate enough about it

Figure 1



<u>Section 2: Interactive Exhibit Engagement</u>
Section 2.1 – Exhibit Elements

Each of the planned elements for the DenCITY exhibit is mapped in the floor plan in figure 1. Each of these elements is also described in detail in the sub-sections that follow.

Section 2.1.1 – Activity A: The Holdin' Weight Bridge

The primary entrance to DenCITY will be "The Holdin' Weight Bridge." Visitors will cross a series of lily pad style floating foam blocks like those typically found in water parks. They will have ropes and handholds fashioned to resemble the cables and towers of the Golden Gate Bridge to help them across. Since we do not actually want anyone getting wet, thick plexiglass will cover the water with cutouts sized perfectly for the foam blocks. This will allow the foam to sink and rise in the water when weight is added or removed but not allow anyone to fall into the water. We are planning to have both an easy and difficult path. Additionally, the blocks of the bridge will be fashioned to look like ice cubes.

The Holdin' Weight Bridge will be a great introduction to DenCITY, both because of the fun and spectacle of the activity as well as its very relatable premise. Everyone knows that ice floats in water, but how many people have ever considered why? For visitors who what to know why this phenomena occurs, there will be a video screen next to this experience that explains how when water freezes, its molecules spread further apart and it becomes less dense than the same volume of liquid water, causing it to float to the top. A secondary, universally accessible entrance will be provided for anyone unable or unwilling to cross the bridge.

Section 2.1.2 – Activity B: DenCITY Skyscrapers

The most striking visual when guests walk into DenCITY will be its large, colorful skyscrapers. In this exhibit, we plan to make two sixteen-foot-tall density columns, five feet in length and width. There will be a control panel giving various options for both liquids and solids to add to the skyscraper. Differences in density between the liquids will create clearly defined layers in the column, while the differences a solid's density will allow it to settle at different heights in the column. Examples of possible substances and objects that could be used in the column are listed in the table 1.

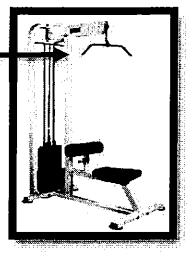
Density Skyscraper: Columns will be fixed with LED lights between the layers to look like real buildings

Table 1

Liquids	Solids
• Rubbing alcohol	• Ping-pong ball
• Vegetable oil	• Gold
• Corn oil	• Wood
• Gatorade	• Tin foil
• Water	• Granite rock
• Grape seed oil	• Football
	• Baseball

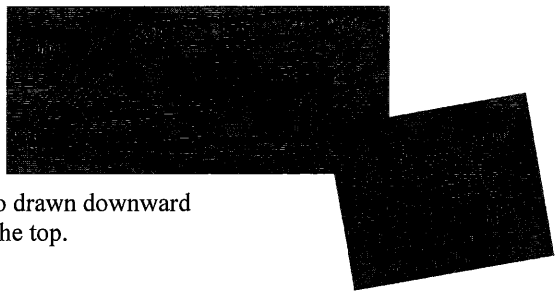
Section 2.1.3 – Activity C: DenCITY Gym

The DenCITY Gym is a great place for everyone to get fit. From novices to elite athletes, this gym has the right density for you. You see each of the



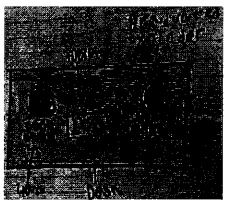
weight machines at this gym has a cable attached to a block that has the exact same volume as the blocks attached to every other machine. The difference between those machines is the material of the block. Beginners could start with the foam or wood block. Stronger guests can try out the higher density blocks – cement, aluminum, or iron. In combination, this exercise will show the user how drastically different the masses of materials can be, even when they take up the same amount of space.

Section 2.1.4 – Activity D: The DenCITY Park Sandbox



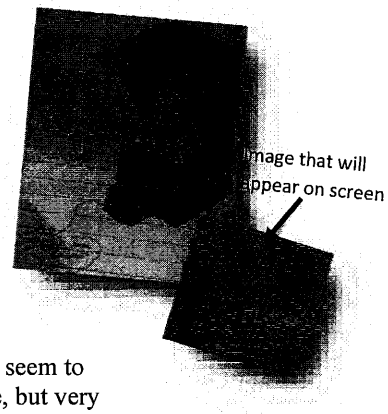
The DenCITY sandbox is a great place for younger kids to play and they don't have to worry about losing their high-density toys in the sandbox. That is because this sandbox can be turned on to allow airflow throughout the box which allows the sand to demonstrate its buoyancy on other objects like a liquid. As with all "buoyancy of sand demonstrations" the DenCITY sandbox will allow its guests to place more dense objects on top of the sand to drawn downward into the sand and less dense objects that are pushed to the bottom push up to the top.

Section 2.1.5 – Activity E: DenCITY Stadium



When you visit DenCITY, you can stop by DenCITY Stadium and bring a friend to challenge to see who will come out "on top." The DenCITY stadium pits two individuals against each other in a game to determine who can better judge the density of an object. The overall rules are somewhat like the card game "War." Each person will have a collection of items in front of them with various combinations of volume and mass, out of view of the other player. Each person then selects an object and places it down a large tube that senses what the object is and keeps it out of play for the remainder of the game. The player that selects the lower density object, comes out "on top" and wins the round. This will be signaled on a screen between the large tubes.

Section 2.1.6 – Activity F: DenCITY Arcade



At the DenCITY arcade, visitors will be able to learn about calculating a density ratio by playing retro-styled arcade machines loaded with the game "PackedMan." The game will have sliders to adjust the mass and volume of an unknown substance on screen. Once the user hits the "start" button, the game puts the two together and the player will see how compact the atoms become given the mass and volume selected. Additionally, the game's output will provide the actual density ratio and a comparison of a common substance of the same or very similar density.

Section 2.1.7 – Activity G: DenCITY Harbor

Some objects tossed in the harbor sink to its murky depths never to be seen again, others seem to pop back! Visitors to the DenCITY Harbor will get to test themselves with a very simple, but very entertaining, crowd favorite – Will it Sink, or Will it Float? A collection of Kansas City themed items will line the boardwalk of the harbor – a Royals baseball, a Chiefs football, replica buildings and landmarks – to be tossed in the water for a test of its density. Since citizens of DenCITY know it's wrong to litter, all items will be anchored to the boardwalk with rope so they can be retrieved and thrown back in.

Section 2.2 – Follow-up Questions Generated by the Exhibit

- Ice floats in liquid water. Do all frozen substances float when placed in a liquid of the same substance?
- How can objects of the same size have such different weights?
- How can density be calculated in oddly shaped, irregular sized objects?
- Does the density of an object change when it is taken to a different planet with more or less gravity?
- We have seen solids suspended in liquids at rest. Why don't we see any solids suspended in gases at rest?

<u>Section 3: Relevancy</u>

Section 3.1 - Applicability to Everyday Life

1. An understanding of density is essential to anyone who lives, works, or plays around water. Knowing what likely floats could save your life.
2. The varying density of air (caused by solar radiation) creates the high- and low-pressure systems that drive our weather. Understanding that movement tells you whether you need an umbrella.

3. Suitcases and backpacks have set, limited volumes. Understanding the density of the items you pack will let you know whether you are likely to sprint through an airport to catch your plane or trudge all the way up a mountain on your hike.
4. Density is often associated with quality. From jewelry to silverware to melons, if in doubt about a purchase, pick the option that is heavier than it looks.

Section 3.2 - STEM Jobs Related to the Exhibit

- *Mechanical Engineers* – These people consider density in every material choice they make for their mechanical systems, products, and inventions.
- *Civil Engineers* – These people consider density in every material choice they make for their roads, structures, and other pieces of infrastructure.
- *Aerospace Engineers* – These people consider density in every material choice they make for the planes and spacecraft they design.
- *Geophysicists* – These people must understand the density of Earth's layers as they study it using gravity, magnetic, electrical, and seismic methods.
- *Doctors and Personal Trainers* – These people must understand the density of different tissues of the human body and how they may relate to weight and health.

Section 4.1 - Durability

This exhibit will be highly durable and stand up to daily heavy use due to:

1. Material/Product Selection – This exhibit will utilize highly durable materials and products. For example, the Holdin' Weight Bridge will be constructed out of materials comparable to highly trafficked water park or playgrounds and the weight machines in the DenCITY gym will utilize products available in commercial gyms experiencing near-continuous use.
2. Simplicity – In general, the materials and products used in this exhibit can be fairly simple in their form, not lending themselves to a lot of fragility. For example, the objects used in DenCITY Stadium could be selected specifically for their durability. One could be a literal brick, if desired.
3. Replaceable Components – Sometimes the best durability is being able to replace something at a low-cost. Much of what need to be replaced or replenished in this exhibit – sand, water, various oils – is quite cheap and easy to replace.

Section 4.2 - Safety

Safety was a huge part of deciding what made the cut and what didn't. While walking across the ice cubes, we were concerned with people falling into water. We then decided to put a clear glass over the water, so it, simply, appears that you are walking on water. There would be small holes in the glass big enough for the foam to wobble a little when you walk on it. The DenCITY Gym equipment can be hazardous if not used properly so there will be signage indicating how to properly change the weights. Also, if someone attempts to lift a weight and it becomes too heavy mid-lift, there will a controlled decent that allows it to lower slowly and not crash down. Finally, the DenCITY sandbox will be placed high enough to discourage children from climbing in and the items to be tossed in will be attached to the frame so they will not get lost at the bottom.

Section 4.3 - Materials List and Pricing

Exhibit	Materials	Total Cost
Density Skyscrapers	16ft tall column; 5ft	$85,000.00
	15 buttons	
	Above 4ft mark glass border	
	Rubbing alcohol	
	Vegetable oil	
	Corn oil	
	Gatorade	
	Water	
	grape seed oil	
	Ping-pong ball	
	Gold	
	Wood	
	Tin foil	
	Granite rock	
	Football	
	Baseball	
	LED lights	
Holdin' Weight Bridge Experience	Custom cut foam (for walking)	$6,000
	Strong glass flooring	
	Water + filter	
	Bungee cord	
DenCity Park Sandbox	Various objects: steel ball, ping pong ball, bowling ball, beach ball	$2,650
	Sand--very fine grade	
	Sand table	
	PVC-pipes for air	

Exhibit	Materials	Total Cost
DenCity Gym	aluminum, wood, cement, iron	$5,000
	Lat Pull Down Machine	
DenCITY Arcade	Steel Glass Plastic Wiring Coding	$31,000
DenCity Stadium	Objects of various densities: pennies, rocks, marbles	$3,500
	Large glass beakers	
	Table for two people	
	computer screen	
DenCITY Harbor	Model buildings $1236	$2,186
	Water tank	
	Shelf (19 pieces)	
	baseball, football	
Total: $135,336		

RoboRevolution

Creativity and Inspiration

Our exhibit is all about robotics. Robotics is the science and engineering of machines to make decisions through computer programming. It is used to solve a problem or make life easier. All six activities in our exhibit are based on robotics, and we plan to have different activities that showcase the STEM concepts taught through robotics. Those concepts include mechanical engineering, electrical engineering and computer programming.

The first STEM concept we have is mechanical engineering, which is to design, test, and build moving parts such as robotic arms or other limbs. The two exhibits for this STEM topic are Miniature Sensor Maze and the Robotic Arm. The sensor station is a fun hands-on activity where you can see sensors move and interact with the maze. The Robotic Arm lets you see how the mechanical parts of a robot work while playing different games. Mechanical engineering is an important part of robotics.

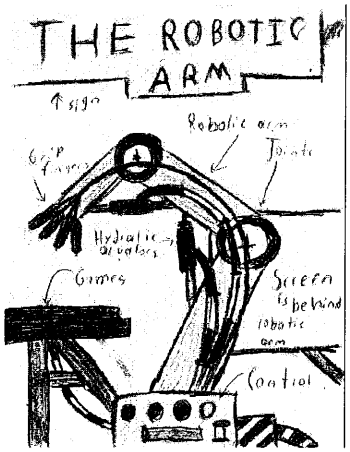
Next is electrical engineering. Electrical engineering is designing, testing and building parts that gives a robot the power necessary to work correctly. Electrical and mechanical engineering work hand in hand. Our exhibit for this STEM concept will be VR (Virtual reality). VR demonstrates electrical engineering by using a VR headset to see the robots in action and other options you choose. Lastly, Robotic Circuits demonstrate electrical engineering because you put together an electric circuit to get a robot to clap. Without electrical engineering you would not have robotics.

The last STEM concept is computer programming, which is making step by step instructions for a robot to follow and to allow it to make decisions to complete a task. The exhibits that use this STEM concept are Cubelets and Ask Athena. Cubelets is an example of computer programming because you create an action by snapping together blocks. These blocks can do many actions such as spin, turn, move, rotate, and other amazing things! Lastly, Ask Athena is a robot where you can ask questions. She also demonstrates computer programming because you have the chance to see the coding and thought behind her answers. By learning computer programming, users will understand how robots make decisions.

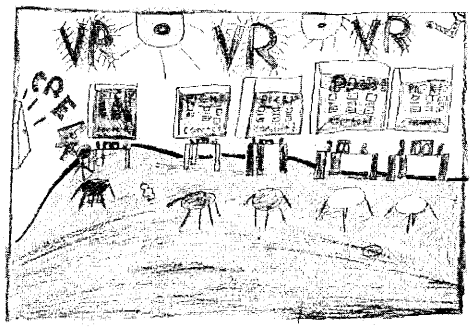
The reason we decided to choose robotics is because robots are everywhere in everyday life. We also know that robots are complex, educational, and offer young children and teens many ideas for future job opportunities. We were also inspired by our experiences at Challenge (our gifted program). We often use Makey-Makey and Scratch to learning computer programming concepts. Robotics can also be present in our everyday lives, and they are a huge part of our future. Just look around, there are robotics everywhere!

We had tons of ideas for our activities, but only the six we picked stood out to us. We didn't use our STEM Concept Mathematics because we couldn't find any fun activities to do with math and robotics. Next, we didn't use the activity idea Lego Robo Fun because of copyright and safety reasons. Also we decided to not use the activity idea Andy the Robot because he wasn't hands-on and was too expensive. Lastly, we decided not to use Parkour Madness because we only had a limited amount of space and Parkour Madness took up too much of it. We think the ideas we kept are winners though!

Interactive Exhibit Engagement

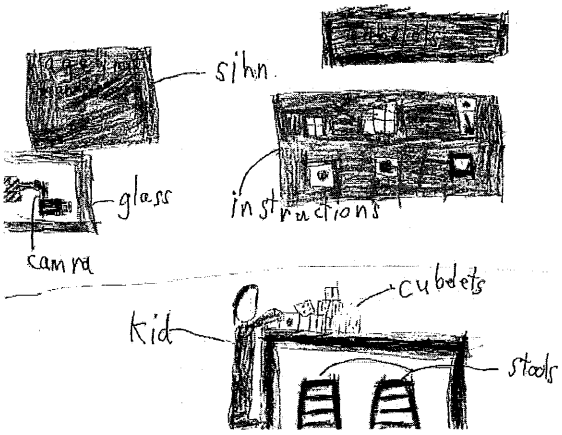


Our first activity is called **The Robotic Arm**. This is similar to a friend that plays different games with you. The games The Robotic Arm can play with you are chess, checkers, tic tac toe, and connect 4! These games are for all ages! The things that make this element hands-on is that you get to play the games with the robot. Users who participate can learn how moving parts work with engineering. Kids will be able to learn about mechanical engineering, by watching a video that shows users how this arm works. This activity would be difficult for kids 0-6, because they would not be able to understand the concepts of mechanical engineering. However, kids 7-18 would be able to understand the STEM concepts. In the end, it can be fun for anybody to play the games with The Robotic Arm.



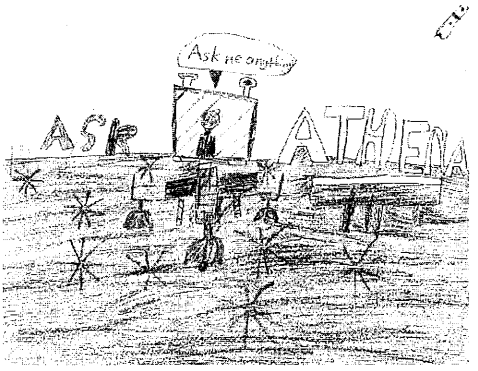
The next activity is **Virtual Reality**. In this activity, you are able to put on a Virtual Reality headset and choose what robotic scenario you will be in! You are also able to see robotic machines. How does it work? First, you press a button to choose your robotic scenario. Then you just sit back and enjoy the learning. The scenarios you will be able to choose from are the Toymaker 3000, Underwater Exploration, Temperature Robot, Flying

Probe, and Rover on Mars! Learning is incorporated into this activity by seeing and learning how robotic machines work all around the UNIVERSE! The Virtual Reality activity can appeal to kids of any ages, because most people will like virtual reality activities. Users will learn about electrical engineering and computer programming through these simulations. The Virtual Reality activity can appeal to kids of any age, because most people will like Virtual Reality appliances.

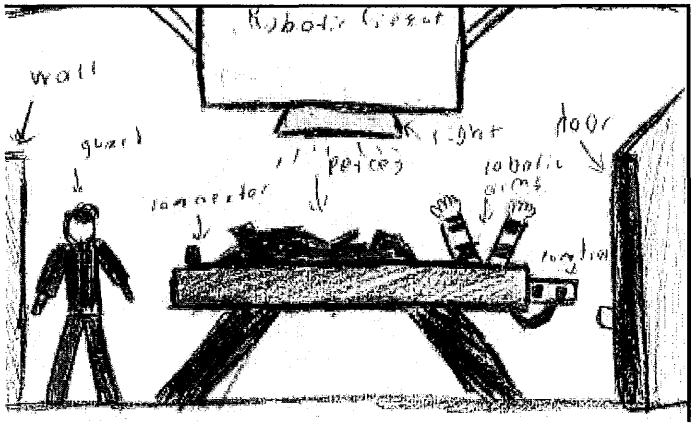


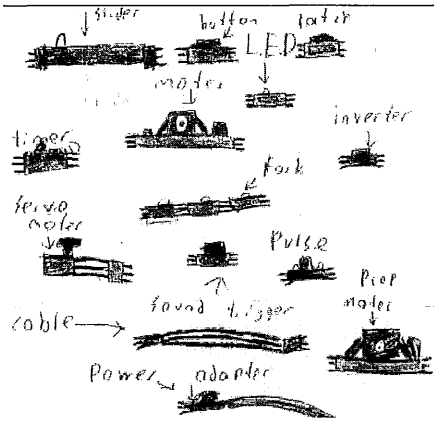
The next activity is **Cubelets**! Cubelets are blocks you can snap together and program so they can do different actions like turn around, spin and move forwards or backwards. Each Cubelet has a different responsibility, some of them are sensor, outputs, or inputs. This can be a fun activity because it is hands-on, interactive, and fun for everyone. The Cubelets are hands-on because the user puts blocks together that makes a robot. Users will learn about computer programming by making the Cubelets follow a set of directions. Learning is built into the activity because of experience with sensors, inputs, and outputs. Cubelets would not be suitable for younger kids for safety purposes because they might stick the wrong things together or put them in their mouth. However, older kids will have a great experience with putting sensors, outputs, and inputs together to make a robot!

The next activity is **Ask Athena.** Ask Athena is where you get to ask a robot factual questions and get answers right away. However, if you ask Athena questions that are opinion questions such as "What's my favorite color?", she will not be able to answer your question and she will have to guess. At the activity you get 10 minutes to have a conversation with Athena and ask her the questions you have always wanted answers to. Users will also learn about a robot's thinking process by reading a poster that explains programming specifically for a robot to make decisions! Learning is incorporated into this activity because even though you're simply asking her questions, you can also see her thinking process by reading the poster about her programming. Ask Athena will appeal to all kids of different ages. Younger kids will be able to talk to a polite and smart adult. However, kids 10-13 and teenagers will have many different types of questions to ask. Everybody will have FUN!

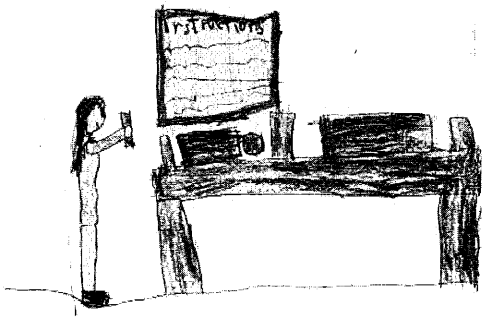


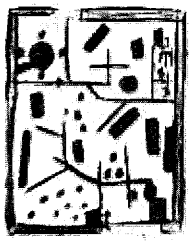
The next activity is **Robotic Circuit**. In this activity you will be able to snap pieces together to make a circuit that will allow a robotic arm to complete a task! On level 1, if your circuit works, the robotic arms will clap. On level 2, if your circuit works, the robotic arms will wave and say "YAY!". The hands-on elements at this activity are designing your own circuit with sliding pieces together to complete a circuit. Users will learn how to make a simple circuit that can then power a program! Learning is built into this activity because you are learning about circuits, electricity, and electrical engineering. Robotic Circuit will appeal to kids of all ages. It will be fun for younger kids, because they will like to build and put pieces together that will make robotic arms do certain actions like clap or wave. Older kids will have fun and they will quickly understand how it's powering the robotic arms.





Miniature Sensor Maze is the next and final activity. Miniature Sensor Maze are little robots (like Sphero or microbots) going in and out of a maze that represents a house. This activity is fun because you get to create your own maze by placing miniature furniture in different locations. Then the robot uses its sensors to move through the house without hitting any objects. This activity is hands-on because the user gets to move the furniture to create a maze. Users will learn the science behind robotics, such as sensors, and there will also be a poster that will tell how the robot makes decisions. Learning is incorporated into the activity because it teaches how the robot can be programmed to make decisions. Miniature Sensor Maze appeals to age groups to kids 3-13 because kids 8-13 will be able to code, and kids 7 and under will have fun moving the furniture.

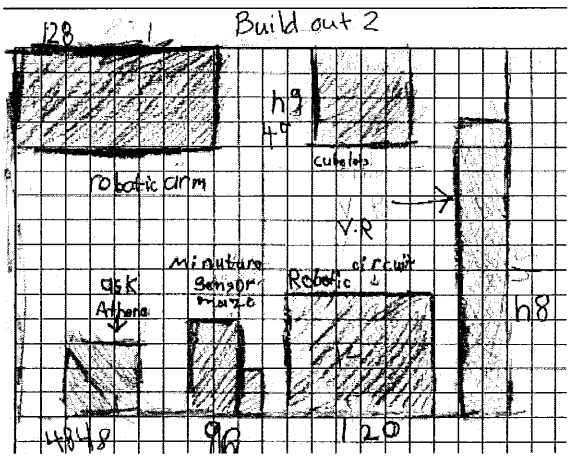




Birds Eye View

Here are some **questions** guests may still have after visiting our exhibit:

1. How are robots created?
2. Can I make a robotic circuit at home?
3. When can robots be the most helpful?
4. How are robots present in our everyday life?



Floor Plan
Build Out Area 2

Relevancy

Robotics are all around us. If you come to our exhibit, you will see how robotics are used in our world today. We use robotics for creating things for war, such as Unmanned Aerial Vehicles (UAVs). Robots are also for making things like toys, or assisting in building cars. Finally, they can do things like cook, clean, and design buildings. See how many ways robotics are used in the real world by visiting our exhibit at Science City.

If you've ever wanted to work with robotics, there are plenty of jobs you could do. Jobs for robotics include mechanical engineering, robotics technician, industrial robotics engineer, or computer programmer. A mechanical engineer designs power-producing machines such as gas turbines. An industrial robotic engineer designs robots to do tasks too dangerous or too dirty for human beings. A robotics technician builds, maintains, tests, and repairs robots.

Finally, computer programmers create the step by step instructions robots have to follow to complete a task. Robotics are difficult to learn, but there are lots of interesting careers out there if you're willing to work hard and learn about them.

Constructability

In designing the exhibit, we made sure that it would be durable enough for kids to use every day. First, the robot arm was more expensive and made of better materials. By purchasing more expensive items, they are higher quality and will withstand daily use for years. Also, the maze walls, in The Mini Sensor Maze, are made of higher quality wood to ensure the exhibit will last for years to come. Last, but not least in the VR room we mounted televisions to the wall using mounts that can hold up to 400 pounds. In conclusion, we chose to spend more money on higher quality materials for more durability.

While designing the exhibit we had to make sure it was safe for all ages. First off, we mounted the televisions on the walls so they cannot fall when struck by someone bumping into them. Next, in the Miniature Sensor Maze we glued down small objects so younger kids do not choke on them. Then, in the VR exhibit, we added chairs for participants to sit in, so kids wearing headsets don't run into each other and get hurt. In conclusion, we care about our exhibits, but we care more about our users so we want them to be safe.

Budget:

Activity 1:Virtual Reality		**Activity 2: Robotic Circuit**		**Activity 3: Miniature sensor maze done**	
5 VR Headsets	3,500	plastic	77.94	5-Foam	160
5 Apple IPhone 11s	5,000.00	wires	14.99	5-Gorilla Super Glue gel	70.00
5 wrought Iron hook	82.05	Power source	188.10	Apple Iphone11-5	5495
Samsung TV-5	8480.00	2 Robotic arm	100,000	2- mini furniture set	13.00
Tv mount	500	30 magnets	900	2-5l mini furniture set	58.00
				15-brass sheet	146.55
				3-Fabric	50.97
				wood square pieces	38.97
				1 inch wooden blocks-2	21.58
Total	**17,562.50**	**Total**	**101,181.03**	**Total**	**6,054.07**
Activity 4: Ask Athena		**Activity 5: Cubelets**		**Activity 6: The Robotic Arm**	
computer desk	546.98	cubelets-5	8,670.00	Articulated Robotic arm	50,000
Yunbaoit Red Timer	19.00	table	159.62	TicTacToe	29.99
Bolts, Screws , and nuts	9.00	paper	25	Connect 4	11.99
Bonaok wireless	30.00			Checker board	8.95
Computers	4567.56				
Total	**5172.54**	**Total**	**8,855**	**Total**	**50,051**

Various Building Material Cost: $50,000

Overall Total Cost: $235,261.06

Explore the Wonders of Coral Reefs!

Section 1: Creativity and Inspiration

Section 1.1 – Main Idea

It would be easy to assume that Earth's largest living strcuture and oldest ecosystem is nearly immune to harm. Unfortunately, that assumption is false. Coral reefs are the most biologically dense and diverse ecosytems in the sea, yet their existence is also quite fragile and can be negatively impacted be the choices we humans make on land. This exhibit will share with its visitors the immense value and immeasurable beauty of coral reefs and show what we need to do to ensure their survival.

Section 1.2 – STEM Principles and Concepts

The following describes how *Explore the Wonder of Coral Reefs* will teach STEM principles and concepts to its guests.

Science – The study of coral reefs provides an extremely interesting intersection of biological sciences, environmental sciences, and conservation sciences. The basis for most of a reef's value is the amount and diversity of the life it supports. That life is supported by a set of environmental conditions that must be maintained, and maintaining that environment depends upon minimizing human impact on the reefs.

Technology – Our oceans generally, and our coral reefs, represent some of the last and best new explorations left on Earth. Unlike with many of the hard-to-reach points on land, our oceans require technological advancement to be further explored. Learning about coral reefs requires visitors to exposed to fascinating deep-sea technologies – submarines, imaging technology, echolocation, and much more.

Engineering – Environmental engineering is a branch of engineering that focuses on protecting people from the effects of adverse environmental effects. This discipline is extremely important to coral reefs since humans benefit from healthy reefs for economics and recreation. Designing ways for reefs and humans to better coexist is critical to long-term reef survival.

Mathematics – The results of environmental changes on coral reefs can be massive. However, noticing these changes before it is too late can be difficult because the changes occur in small amounts over an extended period. Mathematics is critical to the conservation of coral reefs because it helps us note these small changes in more concrete ways like precise calculations of water temperature, concentrations of dissolved gasses in water, and the presence of certain chemicals.

Section 1.3 – Inspiration

We were inspired to create this exhibit because of the shared passion it evoked in our class during discussions. Not only were we all blown away by unique visuals and experiences that could be created using coral reefs, but we also felt a strong sense of purpose in developing the exhibit. We believe this exhibit can teach, entertain, and, importantly, leave its visitors with a clear call-to-action on *how* and *why* they can help preserve our coral reefs.

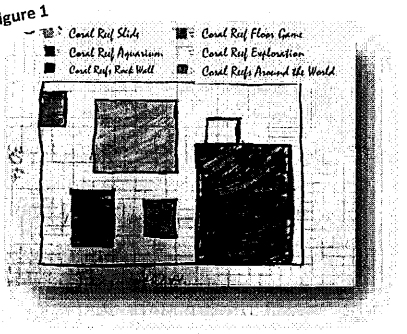
Coral reefs are incredibly beautiful gifts of our natural world that we are seeing literally die off before our eyes. This change is not happening over centuries or millennia. Substantial changes are occurring each year. While we are very interested in raising awareness of our impact on the reefs specifically, we also hope this issue and exhibit will help people consider *their* environmental stewardship as well.

Section 1.4 – Discarded Ideas

Although we like to think that all our ideas were great, some were not used in our final submission.

1. We were excited about doing an exhibit on space but felt that the exhibit would be an overshadowed afterthought standing next to the Arvin Gottlieb Planetarium.
2. Another idea we considered was bees, their necessity to life, and our impact on their populations. However, considering that they had similar themes, the class was more excited about coral reefs.
3. Within our existing theme of coral reefs, we decided to let go of an idea for a video display explaining how and why coral reefs are dying. Though the information was good, we felt it lacked hands-on engagement.
4. An exhibit on electricity excited us when the power went out at school for a few hours but didn't' think it would stand out as much as an exhibit on coral reefs.

Figure 1

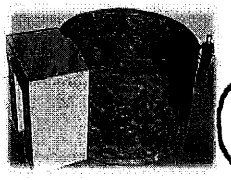


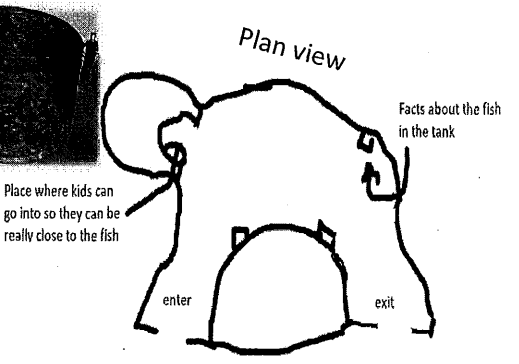
Section 2: Interactive Exhibit Engagement

Section 2.1 – Exhibit Elements

Each of the planned elements for the exhibit is mapped in the floor plan in figure 1. Each of these elements is also described in detail in the sub-sections that follow

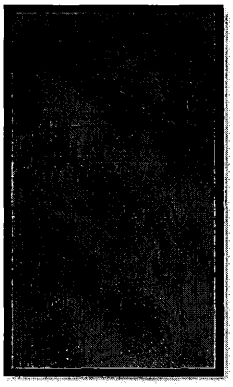
Section 2.1.1 – Activity A: Coral Reef Aquarium



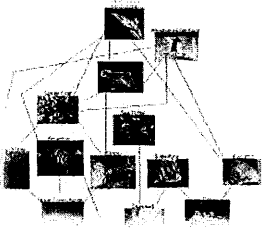


While there will be models, diagrams, other abstract elements included in the exhibit, one of our primary goals was to show visitors what a coral reef really looks like. To do that, we will create an immersive coral reef aquarium in which visitors will feel as if they have been transported from Science City underwater into a vibrant and thriving coral reef complete with many of the animal species that make coral reefs their home – corals, clown fish, sea horses, urchins and even sea snakes! We imagine that guests will want to learn more about the animals they are observing and where they can find these reefs, so we will place signs around the aquarium that will provide information about coral reefs, the aquatic animals that live in them, and where in the world they are located. To further establish the feeling of being in a completely different world, we plan to have nooks guests can step into to be almost completely surrounded by coral and sea creatures.

Section 2.1.2 – Activity B: Coral Reef Climbing Wall

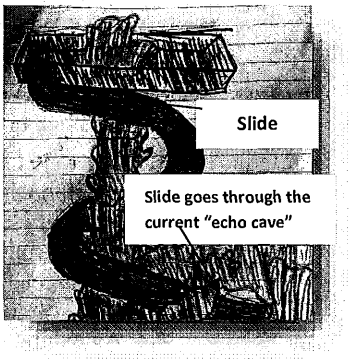


Learning about the individual creatures of a coral reef is very interesting on its own; however, the more complex concept we want visitors to leave with is an understanding of the network of relationships between all the creatures that live there. At the Coral Reef Climbing Wall, the visitor will climb a food web rock wall to discover the codependences that exist in a coral reef. There will be many different paths to take from "Point A" to "Point B," but the climber must always pass between creatures in the predator-prey relationship. As visitors go up the wall, they will be touching the next animal in the food web. Every time they reach a new animal in the food web, it will automatically play short informational prompt about that animal. At the top, the recording will share information on the overall food web and reinforce how negative changes in one area of the web can cause cascading impacts elsewhere. After the climber descends back down, they can go over to a large interactive table that will test their memory on their journey up and across the food web.



Section 2.1.3 – Activity C: Coral Reef Slide

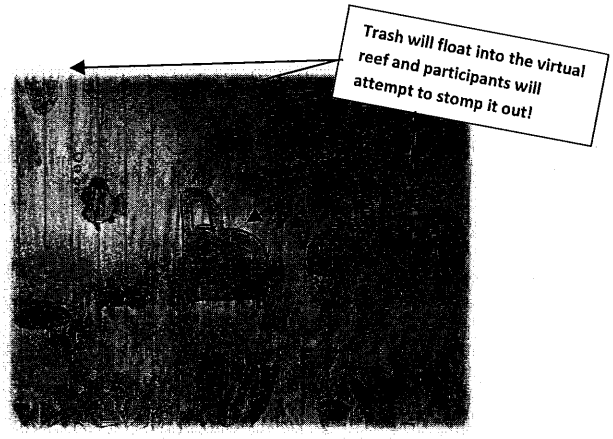
A key theme we want guests to take away from the exhibit is that the beauty and biological diversity of coral reefs are under threat and can be extinguished in a blink of an eye. The Coral Reef Slide will deliver this message in a visually dramatic way. When visitors enter the slide, it will be full of bright, colorful, vibrant coral scenery showcasing the beauty of reefs. However, as 'sliders' get closer to the bottom the coral will quickly start dying. The scenery on the inside of the slide will become stark white from coral bleaching and there will be fewer and fewer coral reef organisms. When the guest exits the slide, they will be presented with information about how and why we are losing coral reefs and what they can do to help prevent the damage.



Section 2.1.4 – Activity D: Coral Reefs Around the World

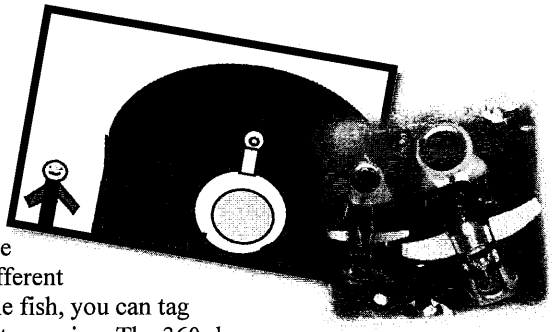
Types of coral, the structures they create, and the organisms that make those structures their home can vary widely across the world. To give visitors a glimpse into what these underwater ecosystems are like, we will create a dark room with a concave wall covered with various sizes and shapes of display monitors giving the guest a 180-degree view. From a control panel, the guest will be able to select different reef locations from a world map and it will bring up actual images of that reef and its plant and animal life. This room's setup will also be used to show other interesting or alarming trends easily captured on video such as time-lapse coral reproducing and coral bleaching.

Section 2.1.5 – Activity E: Coral Reef Floor Game



Through our research, we were amazed to discover that 14 billion tons of trash is dumped into the ocean every year, and that number is only increasing! To help visitors develop an understanding of how much trash is dumped into coral reefs while also making them feel personally empowered to change things, we will provide them a game to stomp out this danger to our oceans. In the Coral Reef Floor Game, there will be an image of a coral reef projected on the floor. At first, visitors will just see the plants and animals that live in the reef swim by. But soon, trash will start to float into the reef. The visitor will then need to stomp on the trash to keep it from accumulating in the reef and killing it. Visitors will notice that over time the trash will come more quickly and in greater numbers so it will be a lot more challenging to keep the reef clean and healthy. This activity will drive home the massive impact humans have on coral reefs. Additional signage will describe how guests can support conservation and how humans can dispose of waste in more sustainable ways.

Section 2.1.6 – Activity F: Coral Reef Exploration Submarines



The Coral Reef Exploration Submarines activity in our exhibit will bring together fascinating technology with the excitement of exploring new, uncharted territory. There will be two replica mini submarines that guests can step into. Once inside, a screen will display a video with simulated imagery of the submarine sinking down into a coral reef to a depth of approximately150-230 feet. The user will then be able to interact with the display using the submarine's controls to explore the reef. There will be an option to pause the screen and highlight the different animal and plant life being displayed. If you want to learn more about the fish, you can tag it and follow it through its journey through the reef and see what it does to survive. The 360-degree view from the submarine will ensure you can always look around the reef. To showcase the threats to coral reefs, there will be options to adjust the temperature of the water along with the pH (acidity). As these are selected, the plant and animal life will disappear, and the coral will turn white.

Section 2.2 – Follow-up Questions Generated by the Exhibit

- Is coral bleaching reversible?
- What happens to the animals living in a coral reef when the reef dies?
- How do scientists and conservations monitor water conditions?
- Why do coral reefs develop in some places but not others?
- Where does all the trash dumped in the ocean go?
- How much of the ocean is still unexplored?

Section 3: Relevancy

Section 3.1 - Applicability to Everyday Life

1. Economics & Industry – Reefs are natural attractions for people and industries are drawn to reefs to provide services to those people. For example, The Great Barrier Reef in Australia has an estimated value of $56 billion and supports around 64,000 jobs.
2. Food Supply – Coral reefs support a huge amount of the sea life in our oceans. This sea life is essential to harvesting enough food for both commercial fishers and subsistence fishers.
3. Coastal community protection – Reefs provide coastal communities a natural physical barrier to rough seas that may otherwise wash away development near the water.
4. Educational opportunities – Coral reefs provide one of the richest ecosystems for study on Earth. Furthermore, the diverse plant and animal species they support contribute to the research and development of health and medicine.

Section 3.2 - STEM Jobs Related to the Exhibit

- *Environmental Engineers* – Environmental engineers are experts that help minimize and manage waste and pollution and have a key role in developing solutions that protect our oceans and coral reefs.
- *Marine Biologist* – Marine biologists lead the scientific study of marine life and organisms in the sea. Much of their work focuses on species found in coral reefs.
- *Oceanographer* – Oceanographers are specialized scientists that study the physical, chemical, and biological aspects of the ocean. Their work is essential to the survival of reefs.
- *Climate Scientist* – Climate scientists' study and monitor the change of our climates on Earth. Understanding changes occur in our climate helps us understand what changes are likely in our reefs.
- *Conservationist* – A conservationist advocates or acts for the protection and preservation of the environment and wildlife. They play an important role in driving human action to protect our reefs.

Section 4.1 Durability

Our exhibit will be quite durable and long-lasting because we have planned for the elements that get the most hands-on wear-and-tear to be of commercial or industrial quality. The Coral Reef Slide and Coral Reef Climbing wall will be of comparable quality to commercial playground equipment and rock-climbing walls. The Coral Reef Floor Game will have people stomping on the thick concrete floors of Science City.

The other elements of the exhibit – Coral Reef Aquarium, Coral Reefs Around the World, and Coral Reef Exploration Submarines – will also be designed for long-term, near continuous use. However, due to the nature of how they are used, these elements will not be required to take the same type of physical pounding the others will.

Section 4.2 – Safety

Safety will be the primary concern throughout our exhibit, but there are some areas that should be especially carefully considered. Under the Coral Reef Rock Wall there will be padding so if someone falls, they will not be injured. Also, while visitors are exploring the Coral Reef Aquarium and Coral Reefs Around the World element it will be a bit dark. To prevent injuries the walkway will be marked with reflective tape. There should also be substantial signage alerting people to "watch their step" when climbing into the mini-submarine experience.

Section 4.3 - Materials List and Pricing

Exhibit	Materials	Total cost
Coral Reef Aquarium	125,000 gallons of saltwater	$135,000
	Water filter and pump	
	tropical fish + plant life	
	3-Inch thick glass + decorations	
Coral Reef Climbing Wall	climbing wall, paint, bungee, harnesses, foam base,led lights,smart-touch technology,	$10,700
Coral Reef Slide	Playground slide, custom framing for stairs, paint, décor	$35,300
Mini Submarine Experience	Mini Submarines, VR software+Wireless adapter.	$43,000
Keeping Reefs Trash Free	Beam Floor Projector, computer software and sensors	$5,550
Coral Reefs Around the World	custom LCD screens (6-10), interactive computer software	$15,000
	Total	$244,550

BEYOND THE RAINBOW

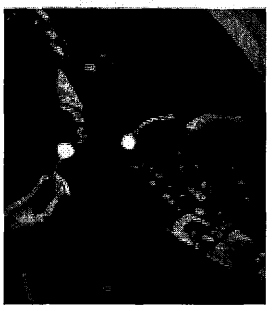
Creativity and Inspiration: Our exhibit, *Beyond The Rainbow*, is centralized on furthering the viewer's knowledge of the light spectrum. Inside the exhibit will be a unique experience of walking through the spectrum, starting with infrared light, then moving into the visible portion of the spectrum, and ending with ultraviolet (UV) and x-ray. The interactive exhibits will excite everyone to learn about the different wavelengths that create the spectrum of light we can and cannot see. Understanding the parts of the spectrum that cannot be seen by humans and the science behind why we cannot see them will be made simple through exhibits that explain wavelengths and the mechanics of the spectrum. Another aspect of the exhibit is learning about what different creatures are capable of seeing that humans are not: like how bees can't see the color red but they can see ultraviolet rays or that pythons use pits on their face to process radiation into infrared vision. *Beyond the Rainbow* also introduces its members to frequency $(f = 1/t)$ of waves and how they change, including the speed of light and wavelength $(c = f\lambda)$. Different types of reflection are also addressed. Specular reflection is very crisp and clear similar to what you see in a mirror and different from what you may see reflecting from a body of water. Another concept the exhibit touches on is total internal reflection. This occurs when the angle of incidence is greater than the critical angle. This equation, $\Theta_c = sin^{-1}(\frac{n_2}{n_1})$, can be used to solve for the critical angle using the refractive index of the materials. Additive color is a property used to predict a new color based on the numeric values of the two colors being combined. This property is demonstrated in the colored shadows exhibit where colors are combined to create white light.

Brainstorming began by sharing all of the team's ideas, whether crazy or not. However, after initially creating a list of ideas for our exhibit, we started to narrow it down. The team's favorite ideas included magnets, weather, soundwaves, and structural concepts. The elimination of structural concepts was due to the possible risk of safety we saw when brainstorming various exhibits. Magnets and weather were both cut because the team did not have as many ideas for interactive portions as we did for the other concepts. Our final two ideas were light and color versus soundwaves. The team then thought of what ideas we had seen submitted in the past for Battle of the Brains and considered how many great soundwave ideas there had been. The vote was unanimous to move forward with light and color after thinking up an exorbitant number of interactive exhibits.

Interactive Exhibit Engagement: At first glance from the outside, *Beyond The Rainbow* appears dull and in black and white. However, the curiosity to know what is really inside will draw in people of all ages to explore our exhibit. Upon entering, the immediate immersion into low-frequency light, such as infrared, can be experienced through many activities. The dance floor is a highly interactive way to first learn what infrared is and what your body looks like in it. Visitors of all ages can hop in front of the camera and see a live video of their motions in infrared on half the screen and normal camera footage of themselves on the other half. Each area of the light spectrum covered in our exhibit will contain a viewing box including several screens that will display images while allowing visitors to observe them in infrared. Visitors will be able to toggle the infrared vision on or off to help them associate heat with infrared radiation. This is where people can learn for themselves how different animals view their own habitats. The final interactive piece of low spectrum light is the infrared scope. In addition, guests will have the option to look at the exhibit through an infrared scope to witness the exhibit and the heat signatures it involves. There will be several interactive components such as a television remote to demonstrate the primary method for wireless communication; a metal wall where guests will be able to leave their heat signatures on, and a plexiglass sheet that other visitors will be visible through when viewed with the naked eye, but will disappear behind when observed with infrared.

In the middle portion of our exhibit, there are two smaller rooms, each of which will highlight a different factor of visible light. One is entirely black, and will elaborate on how black is simply the absorption of all colors. The walls, ceiling, and floor will be coated in Black 2.0 which is one of the blackest paints in the world. The other small room will show how a single color of lighting can affect how light bounces and is absorbed for our viewing in the monochromatic room. All objects will appear to be in different shades of the same color. Younger and older audiences will be shocked at how the colorful room

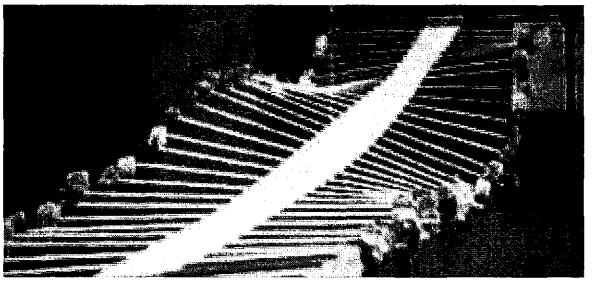
Monochromatic Experience



is muted to only a few shades just by one light. White light flashlights will be attached to various objects in the room so visitors can pick them up and explore the true color of certain items. At the vision viewing center, visitors will be able to view touch screens that simulate seven different types of colorblindness including tritanopia, deuteranopia, and protanopia. The image will begin in normal color and as the viewer selects a type of colorblindness, the image will shift to different coloring exposing how different color blindness can affect people. Viewers will then be asked to identify colors and will see how many they can get right seeing through the selected type of colorblindness. Near the entrance of the visible light section, there exists a water feature that will demonstrate total internal reflection. It will do this by shining a laser through a flowing stream of water. This will allow the light to bend with the water until it is interrupted by a hand. People will be able to enjoy the visual of the water and experience the awe of touching it and having the light from the laser appear on their hand. Learning how the light can be "contained" in the stream of water will relate directly back to the mirror room which is similar but on a larger scale. Within this section, the interactive wave experience will begin to touch on how light moves and what wavelengths create various colors. Visitors will be able to grab a handle connected to the wave and move in a vertical motion to create waves with varying frequencies and periods, which will cause the interactive wave to light up according to the coordinating color from the rainbow. Another wall will give visitors a chance to create colored shadows. This interactive exhibit will be comprised of colored lights that are mounted at angles towards a white wall. When visitors walk in front of the lights colored shadows will appear on the wall. This is because red, green and blue create the additive primaries which, when combined, create white light. People will be able to experience this in action through the large dials available that will adjust the brightness of each color. Viewers will learn that by eliminating one color of light, the shadows begin to change and eliminate elements that were present before. A final station in the visible light area will connect light to the modern world of using displays. Touch screen computers are available for kids to participate in a hands-on game where zoomed-in pixels will be shown. Participants guess what they believe the photo is. After guessing, the photo will zoom out and reveal what the image really is, and how the colored pixels played a part in creating the bigger picture. This will show how visible light is used to mix and project colors that produce an image.

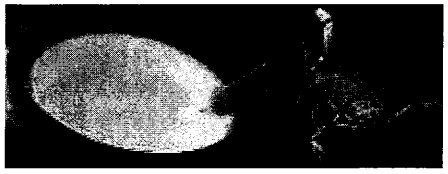
Total Internal Reflection

Interactive Wave Experience



Entering into the high-frequency area, visitors have the option of walking through the mirror room. This piece of the exhibit is a square room visitors can walk through that contains mirrors on every side. Within the room, there will be switches that control each light hanging near the mirrors as well as a big button that will light the whole room. This big button will be used to "expose" the trick the mirrors play with light. Viewers will be able to clearly see the seams in the mirrors as well as their own reflections that are masked when the room is kept dark. The mirror room demonstrates how light can continue bouncing and deceive viewers. This effect illustrates the conservation of energy and specular reflection. Once inside the next area of the spectrum, visitors can take a photo in the simulated x-ray photo booth. The pictures will have inverted colors that provide the excitement of an x-ray without the danger of one. In addition to this, there will be a viewing box with objects that glow under UV lights. Guests will be given the option to view them with or without black light by pushing a button to reveal the glowing effect. This illustrates what

UV Light Viewing Box

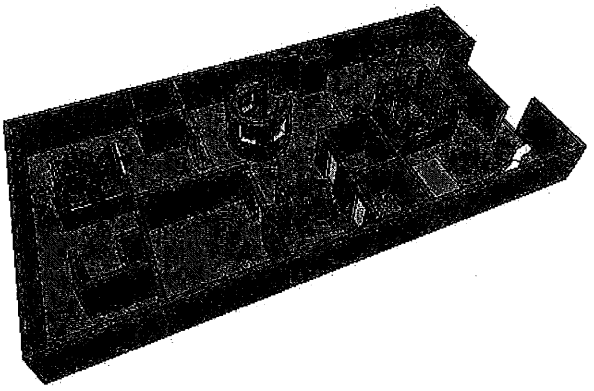


certain animals can see, as well as markings that cannot be seen with the naked eye. Along the whole journey, the spectrum is painted on the ceiling and displays where they are with significant points. Visitors of all ages will learn something as they experience and interact with our exhibit. Many adults don't know much about the light spectrum and are eager to learn along with the younger generation. There are specific exhibits made to appeal to all ages. Whether they just want to dance on the infrared dance floor, experiment with the colored shadow dials or begin to understand the glowing effect UV light can have on objects. There is something for everyone to enjoy in this exhibit. As visitors exit *Beyond The Rainbow,* they will be brought back to the black and white theme that first drew them into the exhibit. *Beyond the Rainbow* will inspire visitors to think about color and how it affects their lives. In addition, the exhibit will encourage them to consider questions such as:

1. Why would an animal need to see infrared or ultraviolet?
2. Why do some things appear to glow under black light?
3. Why is the sky blue?
4. Why is nature primarily comprised of green?

Relevance: After visiting *Beyond The Rainbow,* kids will be excited to look into how the light spectrum is important to their life. They can get an x-ray at the doctor's office and know that the waves come from the high-frequency side of the spectrum, or observe UV light in action after getting a sunburn. When using a TV remote, kids will know what infrared rays are and why they cannot see them. Within the United States, approximately 7% of men and 0.4% of women have some sort of color blindness. This makes the viewing box highly relevant in explaining to audiences what being colorblind is like and how many different types exist. Kids can look forward to pursuing careers such as an x-ray technician, optics engineer, optometrist or astronomer. All these careers require extensive knowledge of the light spectrum and how light waves react with different lenses and materials. Specifically, an optometrist needs to be able to not only diagnose many eye conditions but also understand them. Within the visual light section of *Beyond the Rainbow,* viewers will be able to look into what different variations of colorblind conditions look like for different people. Optical engineers are responsible for optical systems and technology. This includes cameras, lenses, and telescopes much like the infrared scope people have the chance to interact with in the low-frequency area.

Constructability: *Beyond The Rainbow,* while large in area, will be easy to maintain. Each area demonstrates what the light spectrum is like in real life while also being safe and fun. In the infrared section, the exhibit mainly consists of cameras with a live feed out onto a bigger screen or the placing and securing of pre-bought scopes. These are both simple tasks to accomplish, and effectively communicate what infrared is on a fun and interactive level. The live feed camera is a high-quality camera that will be able to run without overheating much more than the required 6 hours of use daily. Both of the smaller rooms in the center portion of the exhibit would be easy to maintain and create. Being that the only supplies for the black room needed is the black 2.0 paint and the monochromatic room can be filled with varying décor, but the key piece is the sodium vapor lamp in order to produce the monochromatic light. Safety and upkeep relating to the sodium vapor lamp is quite simple. The lamp takes 3 minutes to warm up and can last 3,000 days being on for 6 hours a day. Safety issues are only introduced when the lamp is damaged. Making sure the bulb is not cracked and knowing that it still may work even if damaged is key in providing a safe experience. The colored shadows area will only require a white wall, red, green, blue lights and the 3 large dials that control the lights. Having large dials that move slowly will ensure that the bulbs will be okay when turned off and on repeatedly. It will be a gradual transition from off to on that the dials control. Inside the mirror room appears to be a large commitment to keeping clean, however, installing a plexiglass guardrail through the whole room will keep fingerprints off the mirrors and allow for less maintenance. The guardrail will not take away from the effect of the mirror room, but simply allow for easy maintenance. The switches mounted in the mirror room will control each hanging light and the rooms ceiling lights. This will be a simple way to engage kids into what the reflection looks like with one



light on versus all the hanging lights on. Each of the viewing windows will be incorporated into a bigger structure or varying layouts but keeping the same concept of having viewers look into and see how the specific parts of the light spectrum is seen. The safety of people in the exhibit is always the priority. At first, the "X-ray photo booth" may seem dangerous; however, the team has realized this and opted to keep the educational aspect of x-ray waves while removing the danger. Inside the booth, viewers will see themselves in an inverted color which is not a true x-ray it just mimics the color scheme x-ray machines use. For the exhibit that uses lasers to teach about total internal reflection, only Class 2 lasers will be used. This type of laser is the same as what is used in a standard laser pointer. There are no risks of skin or material burning with a Class 2 laser. The only risk is if a person was to deliberately stare into the beam. The way this exhibit is structured makes it difficult to get the laser to your eye. The laser beam is very low risk already being Class 2 and is well contained in the stream of water.

Cost Analysis:

Part	Total	Part	Total	Part	Total
Walls	$10,000	Pixel Play	$21,000	Paint	$5,000
Black 2.0 paint	$500	Monochrome room	$5,500	Information panels	$10,000
Mirror Room	$22,000	Infrared scope	$1,000	Waterfall	$5,050
Lighting	$15,000	Interactive wave experience	$21,000	Viewing Windows Infrared	$5,000
Infrared dance area	$12,000	X-ray photo booth	$10,000	Viewing Windows Visible	$31,000
Viewing Windows UV	$7,000	Seating Area	$5,000	**Final Cost**	**$207,050**