The Wonder Factory

Report 1

Team 5

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1 BACKGROUND

1.1 Introduction

The Wonder Factory is a mobile unit that provides communities with opportunities to present classroom learning through interactive displays. This capstone team is determined to plan and develop an interactive display that educates the user about one or multiple Science, Technology, Engineering, Art, and Technology (STEAM) concepts. Throughout this report we will be discussing the background of the project, determining customer needs, having the customer rank those needs, researching existing infrastructures and learning tools to help us better understand and develop a new design.

The Wonder Factory has asked our capstone team to develop a new display that will be beneficial for the youth and young at heart. Flagstaff currently does not have a science center that enables the community to be engaged with STEAM resources. Jackee and Steve Alston have taken it upon themselves to develop a place where anyone can "learn through play". This project will positively influence the Flagstaff community in getting their residence more active with STEAM but at the same time learning curriculum through fun interactive tools.

1.2 Project Description

Following is the original project description provided by the sponsor.

"Your task is to generate lots of interactive display ideas and to ultimately design, build and test one final display ready for public consumption."

1.3 The Wonder Factory

The Wonder Factory in Flagstaff, Arizona represents STEAM in all its forms through interactive displays and learning modules. Originally Jackee and Steve Alston decided to forefront this operation because Flagstaff does not have a center that gets the community more interactive with STEAM concepts. The main goal of the Wonder Factory is "to lead the next generation of young minds into their place as the thinkers, the makers, and the creators of the future through hands-on interactions with science, technology, engineering, art, and mathematics."

> *"This project involved the design of a completely new interactive display. There are different existing systems but there needs to be more."*

1.3.1 The Wonder Factory Structure

The Wonder Factory is currently a mobile exhibition that has different events year around. These pioneering qualities of a science center give access to rural parts of northern Arizona to become more educated about STEAM concepts. This mobile unit provides the opportunity to continue this outreach, even when a place of operation is established.

The existing system has the following main features:

- Mobile unit for the remote exhibitions
- Maker's space and builder's lab
- Toddler space
- Exhibit local space

For future planning the brick and mortar operations will include rooms designed as follows:

- Doctor's room
- Scientists Lab
- Engineer's corner
- Geographer's shop
- Storyteller's café
- Naturalist's Playground
- Toddler space

1.3.2 The Wonder Factory Operation

Daily operations can be translated into monthly events held by the Wonder Factory. In the future when they have a building this might change based upon types of special events or include daily operations. Most of the events are not continuous and are up to change based on demand.

These events include:

- GEE WHIZ TRIVIA NIGHTS
- Factory after hours
- Wonder ambassadors
- Toddler times
- Field trips
- Birthday parties
- Special events hosting
- Tech bash shark tanks

1.3.3 The Wonder Factory Performance

The Wonder Factory is the pioneering center in America. The overall analysis below shows that there is room for innovation and extension of the preexisting Wonder Factory. In all cases, there is room for improvement in creating educational interactive displays that create learning through fun. The community is eager to participate and come to the center but the goal should be retaining the consumers and making

them want to come back or buy a membership.

The market analysis for the wonder factory includes these statistics:

- 71% of the people think that the attractions are not suitable for children to have fun and learn
- 84% of the people say that they would visit the wonder factory
- 58% of the people will go there once a month (these are the membership people)
- 49% people say that they want interactive exhibits rather than visual ones.
- 77% tourists spend 2.6 nights here and 235 of them will travel with children

1.3.4 The Wonder Factory Deficiencies

When interviewing Jackee, she had mentioned they were lacking in a toddler dedicated space. Since most capstones teams are more focused with upper level learning such as projectiles and wind vortexes they do not have a simplistic module for the younger generations. This could be a potential red flag when trying to determine customer expectations. The current system in place is gaining momentum with the incoming interactive displays but if the Wonder Factory is lacking in an area we want to investigate potential solutions.

2 REQUIREMENTS

There are multiple requirements that team members should be considering throughout the procession of this project. Safety is priority when generating up to 100 designs for the interactive display. Team members must interact with the clients throughout the completion of this capstone sequence and raise a certain amount of funds. Before the completion of the project we must select, design, build, and test one final design.

Since the display will be expected to be used every day, we should test accordingly and make sure durability and strength are up to the highest standard. The Wonder Factory team should be following these standards to maintain complete clientele satisfaction throughout this capstone project.

2.1 Customer Requirements (CRs)

This project is based on STEAM learning and awareness using a playground theme. Customer requirements (CRs) are parameters that help engineers focus on the client's vision and standards of the design. By following these CR's the project will have more detailed information so engineers can translate these CRs into engineering requirements (ERs).

The customer requirements are listed and described below:

Safety & Simple instructions:

The knowledge of safety and precaution must be accessible to all the members so that risk factor is minimized. Taking the necessary steps to figure out potential dangerous hazards is essential to making the interactive display as safe as possible. We want to establish a level of reverence with the community who are going to be using this interactive display. Depending on the design of the project we must account for safety, always, since the customer rated this at a 5. It is not only in the engineering discipline to design with safety in mind but it is important to the customer to have a reliable, safe product.

The customers expect the ideology of this design to be STEAM based concepts with the user interface of a "learning through play." The audience that will be interacting with our module will be assumed to have no foreknowledge of STEAM and will perceive the ideas as a student ready to learn. Thus, meaning the design and display are easy to operate and understand so that the consumer does not need to be guided on every step. This also implies that it will be engaging enough that they will not lose interest. The customer rated this as a 5 because in the initial interview they mentioned that displays that attribute complexity fail. For example, a user will become disinterested with determining how to derive a calculus equation because it requires upper level skills of mathematics.

Visual appealing & Easy assembly:

The interactive display should have appealing visual characteristics so viewers are fascinated and intent in participating in curriculum based STEAM methods. The customer deemed this CR as a 4. Visual appearance is vital when designing. It has been known that consumers are more inclined to use a product that looks superior than competitor products.

Complex assembly that requires extensive knowledge is not suitable for the Wonder Factory. As a team, we have considered that they are a mobile unit and do not have time to set up intricate displays. We need to transform complexity into simplicity to make sure assembly methods are easy and scalable for future use. As displayed in the HOQ, easy assembly is rated as a 4 which expresses their concerns to have a display that can be set up within a reasonable amount of time. We also expect that we have fewer resources than other capstone opportunities with engineering laboratories so we need to make sure our display doesn't need extensive assemble or use of high technology machining.

Hands on & Educational:

Hands on expresses a technique that gets the user involved in what they are learning. The customer requirements of hands on and education can relate to one another in this aspect. For instance, if the user is building something to compete they are applying what was taught to accomplish the task. If there is a requirement of interaction, physically, they are applying hands on interface while learning. The customer rated this CR as 5 because many learning practices require hands on experimentation and are proven to help grasp the subject matter.

The educational feature will be incorporated into our design not only because it is a requirement but because it can positively impact the viewer. By gaining more knowledge they can apply it to real world applications and leave the Wonder Factory gaining a sense of understanding and accomplishment. This CR was rated 4 because it is important but if the consumer is just learning and there isn't a fun interactive element then they will not be motivated to learn.

Element of surprise & Wow factor:

There were some concerns about wow factor and element of surprise being similar when presented to the main stakeholders. In the future, this issue needs to be addressed but for now we will keep both since the team decided there might have been miscommunication with these customer requirements. While "wow factor" is more of being inspired, and engrossed with the display, the element of surprise corresponds when users are interacting with the display and something unexpected happens that excites them.

Of these two customer requirements, the wow factor was rated at a 5. Jackee stressed this CR as important because it makes the interactor remember that display or learning module through amazement and wonder. Wow factor sets it apart from other interactive displays in a sense that it embodies something new and appealing.

The element of surprise can be formulated into visual outputs that introduce the user to something unknown. This learning technique can be successful in the aspect of making the consumer want to explore the unexpected. This customer requirement was averaged at a 3. With further explanation, this CR might change in further reports.

STEAM learning concepts & Narratives:

In the project description, we are asked to make an interactive display that deals with STEAM concepts. We decided this was essential to incorporate STEAM because it is the backbone of the project but we want to apply these learning concepts in one or more forms. Meaning there could be more than one STEAM

concept in our design. This CR is rated as a 4 due to the freedom we have and since STEAM concepts tend to be interwoven into each other.

When interviewing Jackee we had questions regarding a hypothetical narrative and she told us that interactive displays with narratives are more popular than others. This narrative could bring awareness to issues of daily life or around the world problems that need to be solved. The rating of 4 was the given for this CR because narratives could prompt the user to construct feasible solutions or introduce them to something they didn't originally know.

Multiple visitors & Mobility:

When an interactive display can only interact with one person the message is only received by one individual and the display is limited to collaboration. If we can get multiple participants interacting with the display this inspires team work and gets a message to numerous people. The customer assessed this requirement at 3 because it may not be as important as other customer needs, such as safety.

As the equipment, will be handled by the everyday person, mobility must be contemplated. The interactive display should be easy to handle and required simple movements to shift the display easily. The design should have the provisions to be readjusted per floor spacing and number of consumers present at any time.

Relatable & Durability:

The experimental setup should be based on real concepts and relatable material. We want consumers to gain an attachment through resemblance. This customer requirement is rated at a 4 for a reason, if you can truly relate to something you will associate yourself with that subject. If the user can put themselves into the shoes of an engineer, an artist, and achieve rather than just be visual amused then we have accomplished our initial goal.

When designing for something that will be used every day we need to account for long lasting and superior performance. Good quality raw material and mechanical components should be used for the reliability along with the visual appeal for the best working models.

2.2 House of Quality (HoQ)

The House of Quality below emphasizes customer requirements we determined through an initial interview. These customer requirements were then rated by the stakeholders. In the Appendix is verification that both Jackee and Steve Alston rated these requirements and approved them.

Table 1: House of Quality

Customer Requirement	**Weight (Rank)**
1. Safety	5
2. Hands-on	5
3. Multiple visitor	3
4. Educational	4
5. Simple instruction	5
6. Element of Surprise	3
7. Wow factor	5
8. Mobility	3
9. Easy assembly	4
10. Integration of mult. STEAM concepts	4
11. Narratives	4
12. Visually appealing	4
13. Relatable	4
14. Durability	4

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3 EXISTING DESIGNS

The Wonder Factory has existing interactive displays.

[Use this chapter to describe alternative approaches to designing your new or re-engineered system. Sources for this information include existing product descriptions, catalogs, engineering textbooks, the engineering literature, and the internet. Another very important source for some projects, especially (but not exclusively) for process re-engineering projects, is benchmarking.]

3.1 Design Research

Each member of the Wonder Factory team was assigned to do research regarding existing designs. This research not only had members looking up existing interactive displays but centers where these displays were presented. The goal for this task was to find many different science centers and how they inform the community about the concepts of the displays.

Members had to ask themselves why people were drawn to the displays in the first place, what the user was acquiring from this display, how they were absorbing the information, and the teaching style the center was exercising. The point of these questions is to get a better understanding of what is happening in the underlying methods of teaching users STEAM concepts. Most research was preformed through looking at science center's website and going through exhibits. Reviews on yelp of different centers were helpful in determining popularity and how those centers presented their displays.

3.2 Existing Centers

At the state and national level there are many places were all kinds of people can get introduced to STEAM. In this report, we will be describing these places and how they interact with consumers, what techniques they use, and how they correlate to our customer requirements. By identifying these requirements in different centers, we can see trends that will help our team identify what works when trying to design an interactive display.

3.2.1 Existing Center #1: Science Foundation Arizona

The Science Foundation Arizona focusses on STEAM education. Its mission is to diversify Arizona's economy, link the industry needs with university research, and ensure the education system that creates 21st century workforce. This center has a wide network were students work on robotics. Projects require participants to be hands on and interactive like the customer requirements we determined earlier.

Students not only develop electronics, mechanical, drawing, software, and programming skills, but teamwork and project management techniques. Students can participate in local and statewide competitions that motivate the individual to proceed in STEAM occupational fields. Recently the students made a clever robot that can perform many technical tasks such as: pass a ball, catch it, run down a field and launch the ball. This center makes connections and establishes fun exciting new experiences with hands on opportunities which help its community.

3.2.2 Existing Center #2: Amazement Square

This science center has the possibilities of learning more about structures and buildings and there is the usual experimentation that is also present for hands on practices. They have a separate section for the Harry Potter fandom which includes specific fan foods as well the best restaurants in town. The basic learning is centered for toddlers and children. It is open interaction and multiple members can accomplish a task. The visual scheme is very appealing especially the harry potter section. This science center is more related to science than engineering and it does not have moving mechanical machines. Many members want to come back because of the scientific labratories.

3.2.3 Existing Center #3: Intrepid Sea, Air & Space Museum

This museum is unique in the aspect that it is located on an aircraft carrier base. It has hands-on-displays of items used in everyday life. There are views of the lower living quarters, and an outdoor flight deck with an assortment of fighter jets and helicopters. This center places ordinary people in WWII veteran's lives. Users leave with an extended knowledge of aviation and aerospace. There is a mix of hands on and informational teachings.

3.3 Subsystem Level

The Wonder Factory team had to complete an analysis of components of displays, how they functioned, and which ones were popular. This section will consist of how team members determined why these individual displays are popular based on consumer interface. We will also analyze how the center demonstrates the educational aspect and how the displays correlate to customer requirements.

Each subsystem has a theme: astrology, environmental, and aeronautical. Existing designs under these subsystems are similar in the aspect of what they are educating individuals on but different in how they relay or display this information.

3.3.1 Subsystem #1: Astrology

Astrology is forever expanding since we live in a vast universe. There are several ways interactive displays can educate a community on our planetary system and other aspects of the universe. The following existing designs are different ways learning modules and centers take these displays and illustrate astrology.

3.3.1.1 Existing Design #1: Star Parties: Hands on Optics & Astronomy

Purpose of this hands-on display is to help students learn STEAM through astronomy by putting telescopes in the hands of middle class students. Just before the sunset or 2-3 hours later, students can observe the universe through a telescope as pictured below in figure 1.

Figure 1

The telescope is found to be the best invention to explore the universe. While commercial grade telescopes are bulky, the ones provided to these students are scaled down. Smaller telescopes are useful for understanding the importance of exploration at a more direct and portable teaching tool. These students look at distant objects to have a better understanding of space. Telescopes must have two properties, how well it can collect light and how well it can magnify the image. This gives a visual and hands-on approach to learning which meets our customer requirements.

3.3.1.2 Existing Design #2: Planetarium

The Adventure Science Center has a 63 feet dome called the planetarium consortium. It displays stars in the sky and past stories related to them. This center has other research and experimentation facilities that involve collaboration with anyone willing to explore and investigate. They are delivering other information through visual projection of astronomy and the galaxy we are living in. The ocular presentation is exceptional and the pleasant environment makes people relaxed. The space rides and the stories told here make a very constructive impression in the minds of the participants and they leave with concepts related to astronomy along with visual amusement.

Figure 2

3.3.2 Subsystem #2: Environmental

This section focuses on displays that engage the user with renewable energy, and environmental disasters.

3.3.2.1 Existing Design #1: Catching the Wind

This display has users see what goes into converting wind energy into usable electric energy. The display ties into actual wind turbines and shows the user how energy is converted by having them not only view, but interact in the steps leading up to actual energy use. This display as shown below in figure 3 educates the user of renewables and fossil fuel energies. Multiple users can be at different stages of the conversion

Figure 3

of renewable energy. Users are so drawn to this display because energy is essential to everyone's daily life, we use it everywhere. It also informs of essential placement of wind turbines, boundary layers, etc. Through the exhibit's live data tracking, visitors see which of the museum's own turbines are currently producing electricity and hear about why and how they installed them.

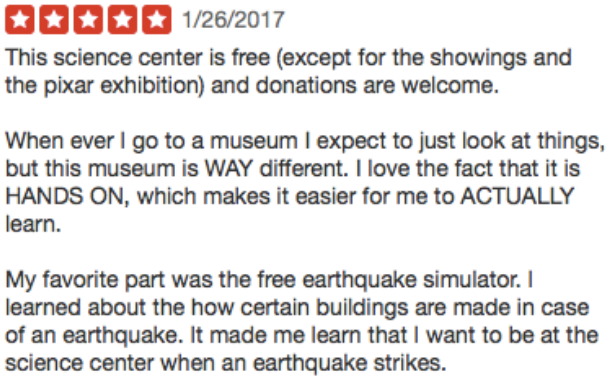
3.3.2.2 Existing Design #2: Flash floods:

There is an exhibit in the Smithsonian that takes the user down a dark hallway that has rain storm sounds. Users read lit up facts surrounding the canyon like walls that give information of flash floods and how fast they can occur. When you walk into the open area that are two plexiglas walls in the surrounding area and then water suddenly fills up the outer walls. This exhibit surprises users by showing them how fast flash floods occur and educating them of natural disasters. This is a popular display because it has that "Wow" factor and element of surprise. It makes the user think and gain a knowledge beforehand when the action takes place. They leave with a level of understanding from both informative and visual aspects. Since it is a walk through multiple users can go through at once all being surprised. The small space out of the safety from the user is water tight and filled with water by pumps.

3.3.2.3 Existing Design #3: Earthquake Simulator

At the California Science Center, there is an Earthquake simulator. This is a popular attraction due to the element of surprise that occurs when consumers engage in this display. This simulator not only shows how earthquakes feel but also informs them about certain buildings and how structural analysis can

protect people from this natural disaster. Illustrated below is a review of someone's experience at this center.


1/26/2017

This science center is free (except for the showings and the pixar exhibition) and donations are welcome.

When ever I go to a museum I expect to just look at things, but this museum is WAY different. I love the fact that it is HANDS ON, which makes it easier for me to ACTUALLY learn.

My favorite part was the free earthquake simulator. I learned about the how certain buildings are made in case of an earthquake. It made me learn that I want to be at the science center when an earthquake strikes.

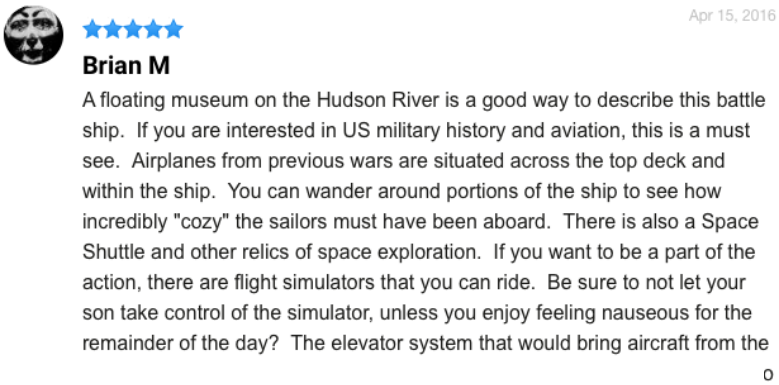
Figure 4

3.3.3 Subsystem #3: Aerospace/Aeronautical

Sss

3.3.3.1 Existing Design #1: Flight Simulation

In reviews from the Intrepid Sea, Air & Space Museum the flight simulator is a very popular exhibit that excites users by giving the illusion they are flying. This advanced technology makes users engaged and in a virtual simulation that has an "out of this world" feel. The review below in figure 5 wrote that it "puts you into the action."


Apr 15, 2016

Brian M

A floating museum on the Hudson River is a good way to describe this battle ship. If you are interested in US military history and aviation, this is a must see. Airplanes from previous wars are situated across the top deck and within the ship. You can wander around portions of the ship to see how incredibly "cozy" the sailors must have been aboard. There is also a Space Shuttle and other relics of space exploration. If you want to be a part of the action, there are flight simulators that you can ride. Be sure to not let your son take control of the simulator, unless you enjoy feeling nauseous for the remainder of the day? The elevator system that would bring aircraft from the

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Figure 5

This interactive display has a hydraulic system that suspends the user in a virtual reality box. There are electrical/mechanical components that tie to software of the flight simulator. This learning technique makes the user not feel like they are learning because it requires the user to play a game.

3.3.3.2 Existing Design #2: Drones

The current focus of Science foundation Arizona is Aerospace & Defense Initiative. This center helps users design commercial unmanned aerial systems (UAS) and associated protocols for safe integration into national airspace.

Unmanned aerial systems are most commonly known as drones. This is an aircraft under remote control by a human or onboard computers. There are many types of drones as pictured below in figures 6 and 7. Drones are used for different purposes like surveillance, aerial photography, and military applications that are dangerous for human beings.

Figure 6

Figure 7

During flight drones usually require a controller. It is like what pilots use to navigate commercial planes for takeoff, and landing. Controllers communicate with drones using radio waves and are controlled by skilled individuals. This center provides hands-on training and experience in designing and aviation navigation. This is popular because it directly involves the users in implementing advanced technology.

3.3.3.3 Existing Design #3: Boeing Jet

Aerospace center for excellence has a Boeing jet for the learning and understanding of participants and it is one of more popular displays. This science center has unique learning concept and it is somewhat like other science centers due to its advance equipment and conceptual learning. The members who want to pursue their career in aerospace technology leave with a vast knowledge of this field after the participation in exhibits of this center and the appealing scientific display urges them to come back again.

the exquisite information about the aerospace engineering and science for the audience and they have exhibits at their center as well as remote arrangements. The participants get knowledge about the aerodynamics and flight concepts. The hands-on experience provided here makes the learning more efficient and they can be for a single person separately as well. They also have

4 CONCLUSIONS

After researching multiple existing centers and interactive displays there is a trend when relating back to customer requirements. Most of the existing displays had a hands-on approach which required the users to be interactive. They also included techniques of taking the user out of their present world and making them learn without knowing it. Displays that have an element of surprise and wow factor seem to be popular because people like to be surprised both visually and physically.

5 REFERENCES

[Include here all references cited, following the reference style described in the syllabus. If you wish to include a bibliography, which lists not only references cited but other relevant literature, include it as an Appendix.]

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planetarium

http://www.adventuresci.org/

boeing jet

Aerospace center for excellence:

http://www.flysnf.org/ace/

APPENDICES

[Use Appendices to include lengthy technical details or other content that would otherwise break up the text of the main body of the report. These can contain engineering calculations, engineering drawings, bills of materials, current system analyses, and surveys or questionnaires. Letter the Appendices and provide descriptive titles. For example: Appendix A-House of Quality, Appendix B- Budget Analysis, etc.]