

1. Research

1a. Initial project definition:

Potential Names: Vitsch

Educational Problem: The educational problem we will be addressing is the accessibility of museums to individuals with disabilities, including individuals with an Autism Spectrum Disorder (ASD).

A museum is an institution where visitors can learn, discover, and experience new information about the world around them. Museums play an essential role in promoting lifelong learning and allowing for in-depth explorations of a wide variety of topics. They provide opportunities for active engagement and learning *from* exhibitions and artifacts in classrooms or books rather than *about* them.

Museums are striving to become more accessible for individuals with disabilities, and most have addressed barriers to physical accessibility and individuals with sensory impairments. Increasing attention and efforts are creating accessibility for a wider variety of disabled individuals, including autistic people, neurodivergent individuals, developmentally delayed, and learning disabled. Individuals with these less visibly obvious disabilities sometimes referred to as “hidden disabilities,” also face challenges accessing museum environments.

Specifically, autistic people are more likely to face barriers to accessing and fully engaging with the museum experience, including exhibits and programs. While there is a broad spectrum of how autism presents in individuals, characterized by specific attributes that present social, communication, behavioral, and sensory differences, changing how they interact, behave, and learn. For example, in a survey of individuals with ASD conducted by Guiconi et al. (2021), accessibility barriers identified included anxiety caused by lack of predictability and excessive stimuli, difficulty organizing, filtering, and synthesizing information, and social expectations within the museum environment.

For this project, we utilize the Florida Museum of Natural History context to visualize how our technology innovation could be applied. Currently, the museum hosts a few autism specific events where individuals can experience the museum at a less crowded, quieter time. There is a need for developing ways to create a more accessible environment and experience that is available at all times.

Initial Product Ideas:

The technology we chose to address the problem of practice we identified is an interactive app with artificial intelligence, navigation, and augmented reality (AR) features. We decided that AR could be used to increase interest and motivation, provide interactions with the surroundings, and increase self-efficacy and autonomy (Vita et al., 2021). While this innovation intentionally focuses on meeting the needs of autistic people, we are using a universal design framework to create an end product that will create an engaging and meaningful learning experience for all users.

The app we will design includes four main components, which are: 1) planning a visit to the museum, 2) navigating the museum, 3) discovering and interacting with the museum exhibits, 4) learning more about the museum topics.

Planning a Visit: The planning component is a critical feature in supporting accessibility to autistic people. Being able to plan and preview the museum experience will increase predictability and anticipation of spaces, allowing a user to feel prepared and less anxious before entering the museum. Users will begin by choosing a virtual tour guide (VTG). By asking questions and responding to user feedback, the VTG will assist users in planning their visit and choosing which exhibits to visit. They will be able to watch videos of the museum spaces to preview what they will see as they follow their plan. Users will have a map and visual schedule of their visit plan. Features of this component will include:

- map of the museum including exhibits, restrooms, restaurant, rest areas, etc.
- planning the visit and route through the museum by looking at a map
- users can also plan in time for breaks, snacks, and lunch
- when a user chooses an icon representing an exhibit or part of the museum, the VTG will provide a description of the environment and what the exhibit includes. For example, the user chooses a video intro of visiting the museum, walking into the museum, buying the tickets, etc.
- recorded social stories of visiting the museum
- videos of the exhibits and other museum locations (gift shop, cafe, restrooms)
- a visual plan of the visit is provided
- a visual schedule of the visit is provided

Navigating the Museum: The second component of the app will be to guide the user through their itinerary when they come to the museum. The virtual guide will describe where the user is in the museum and give directions to the exhibits they have chosen to visit.

- VTG will appear in AR and tell the user to “follow me” along with audio directions

- Visual plan and map
- Wayfinding technology
- Describing where in the museum the user is and what is around them, giving directions based on the pre-planned route or when a location is chosen.

Discovery and Interaction: The third component will provide visual, audio, and interactive content to support the users' learning experience. As users approach specific exhibits, artifacts, or models, the VTG will provide a description of the artifact. Users will be able to request more information. As users can use headphones to access this feature, there is the added benefit of filtering out extraneous noise that may cause stress and anxiety, allowing users to more fully attend to the museum's exhibits and learning opportunities.

Features of this part of the app that will enable users to learn and access the exhibits will include:

- Options for the extent of information provided: 1) just the basics 2) a little bit more 3) tell me all about it.
- VTG will give descriptions of artifacts when users point their device at them. Users will be able to request more information.
- Exhibits can be explored by zooming or tapping features.
- Exhibits may "come to life". For example, in the fossil hall, a user may see a scene of dinosaurs after pointing the device at a skeleton or fossil.
- Interactive activities- eg., scavenger hunt within an exhibit, quiz at the end of the exhibit.

Learning More: In this component, users will be provided with further information and activities related to the topics and exhibitions in the museum. This can be accessed before or after visiting the museum. This feature allows the user to preview the information and gather additional information about specific areas of interest.

- Additional sources of information related to the museum exhibits will include:
 - Interactive, leveled texts (picture books, informational texts)
 - Interactive activities (games, quizzes)
 - Links to articles or websites

1b. Competitive product audit:

Digital technologies have gained the potential for engaging people with autism, especially regarding pragmatic everyday support and therapeutic interventions (Frauenberger,

2015). In a museum setting, phone-based wayfinding technology with AR features address social, academic, and organizational skills – three major goals desired in technology design for those with autism (Putnam & Chong, 2008). Therefore, a product audit of related products is necessary to assess how great the need is for more innovative technologies. An assessment evaluates three main components: application accessibility features, ability to plan a visit (routes, user selection of exhibits, etc.), and effectiveness of learning about subjects of interest. Additionally, the product's ability to send a personalized report or compilation of resources home with the user is an important potential feature. It should be noted that the technology of this category is rare and seldom available on the market. AR applications in current literature are less education-orientated and more goal-centered. For example, using the AR medium as a navigation tool to guide ASD users to employment opportunities (McMahon et al., 2015).

- Brain Power and other smart glasses (Sahin et al., 2018; Wichrowski et al., 2015). While research on assistive technology in the form of computerized smartglasses is educationally beneficial to those with ASD, in theory, the usability statistics are mostly absent. The Brain Power System introduced in 2016 was the first AR smart glasses system, complete with a host of applications from emotion recognition to educational planning. The system itself, Empowered Brain™, is designed with the end goal of overcoming social-emotional challenges to achieve self-sufficiency. The application encourages social interactions and real-world exploration through individualized AR gamification. While Google Glass smartglasses were used in most research, Glass Enterprise Edition (Glass) is the latest iteration of the hardware.
 - One of the few commercially available products of this type, Empowered Brain™ hardware and software costs \$996 annually per system. The proprietary nature of the product most likely would encourage museum education researchers to focus on usability within phone applications as the preferred mode of delivery to the user. However, the effectiveness of the Brain Power System is profound and should be examined to determine compatible characteristics with phone applications.
- Mobile Social Compass aka MOSOCO (Escobedo et al., 2012) – a mobile assistive application that incorporates AR to improve the social skills of those with ASD. This application has only been tested in a classroom-based environment and is only targeting social interaction improvements. Features include a unique identification system, star-progress rating system, self-report forms to document interactions, and social cue FAQ (do's and don'ts of interacting with others). The app compiles the user data to generate a Potential Interaction Partner (PIP) that would be compatible with the user as an interaction partner through the app. The application includes an Interaction Visual

Schedule (IVS) that guides users through the various social skills learned through the app in a stepwise manner. For example, if eye contact is not properly achieved then the app will notify the user of a social misstep along with resources on how to improve.

- In a museum setting, many of the MOSOCO features can be retooled to cater to public learning settings for those with ADS and those who want improved museum learning experiences. For example, eye detection triggering can be repurposed to generate a custom route based on interests, triggering resources to be compiled on a back end as part of a send-home report.
- Mobile Object Identification System aka Mobis (Escobedo et al., 2014) – Mobis is unique from the previous applications in its ability to enable the direct annotation of text, shapes, and audio recordings on top of real-world objects. In addition, Mobis administrators and users can manually specify the level of prompting each user needs. For example, in the hypothetical museum setting, if the user indicates that an increased level of prompting is needed, algorithms with predefined thresholds will adapt and learn for the duration of the visit.
 - Automatic Object Recognition in Mobis combines environment-dependent algorithms with object recognition capabilities through the use of accelerometers. It has only been tested in a controlled classroom setting but is of great interest to researchers involved in customizable guided tours.

Augmented Reality Products for Museums

AR products continue to be designed, refined, and improved to create immersive and interactive experiences at museums. Museums around the world are bringing exhibits to life through AR. These innovations are creating experiences for visitors that are engaging, immersive and

At the Detroit Institute for Arts, you can walk through the Ishtar Gates of Ancient Babylon.



▶ Walk Inside Lost Buildings: Lumin Project at the Detroit Institute of Arts.

The Science Museum of Toronto, MUSE, uses AR to bring dinosaur fossils to life.



▶ Dinosaurs come to life at MUSE, Science Museum of Trento

Several apps have been developed to use AR to provide content specific multimedia information and provide visitors choices for guided tours with a virtual guide. One such application is the Indoor Navigation System with Augmented Reality (INDOAR). INDOAR allows users to access content with their smartphones by scanning a QR code upon entering the museum. Features included an avatar guide, tours of interest in multiple languages, multimedia content, and interactive exhibits.

Our proposed innovations is unique because in integrates the AR technology that museums are using to create immersive experiences with digital supports to provide inclusive experiences for individuals with disabilities. Our innovation is designed to meet the unique needs of autistic people through integration of evidence-based practices, accommodations and modifications provided in a digital format.

1c. User research:

[AbleEyes](#) recommends that hosts of autistic guests share what visitors can expect. Their platform creates and publicizes video models of what to expect videos. For example, what to expect when flying in an airplane, going to the dentist, getting a haircut, etc. This utilization of technology reduces anxiety around being in a new place and not knowing what to anticipate. The videos pay special attention to the aspects of the environment to be aware of (whether it is the credit card machine when discussing when and how to pay or where to wait for your drink at a cafe).

[KultureCity](#) offers suggestions on a mobile sensory station when designated areas for the sensory room are unable to be created. This option provides a great alternative to help make guests feel comfortable and calm.

[National Autistic Society](#) offers training information for museum staff that assist in making any visitor feel welcome and comfortable.

Interviewees:

1. Dr. Matt Schmidt (Associate Professor at the UF College of Education in Gainesville, Florida)
 - a. Academic researcher on virtual environments to support autistic people
2. Stephanie McMahon (Accessibility and Inclusion Specialist at NASA Space Center in Houston, Texas)
 - a. Stephanie is the mother of an autistic daughter, a certified teacher with years of teaching autistic students, an autism specialist, and a museum educator
3. Katherine Davis (Manager of Special Education Experiences and Strategies at the Center of Science and Industry in Columbus, Ohio)
 - a. Katherine has years of experience supporting individuals with differences in a variety of capacities.
4. Dr. Nigel Newbutt (Assistant Professor, UF College of Education in Gainesville, Florida)
 - a. Academic researcher on virtual environments, including museums, to support autistic people
 - b. Scheduled for Monday, February 14th
5. Additional email correspondences from:
 - a. Christina Arnold (Office Supervisor at Santa Fe Zoo in Gainesville, Florida)
 - b. Antonio Delgado (Database Manager at the Thinkery in Austin, Texas)
 - c. Scarlett Hoey (Director of Membership & Development at the New England Museum Association in Arlington, Massachusetts)
 - d. Daniel Ellison (Visiting Lecturer at Duke University in Durham, North Carolina)

- e. Diane Gutenkauf (Senior Assistant Director at the Krannert Art Museum in Chicago, Illinois)
- f. Dr. Kelly Riedinger (Senior Researcher at Oregon State University in Corvallis, Oregon)
- g. Morgan Byrn (Public Programs Manager at the Tennessee State Museum in Nashville, Tennessee)
- h. Rebecca Davidson (Registrar at the Biggs Museum of American Art in Dover, Delaware)
- i. Rebecca Buttigieg (Education Quality Assurance & Training Manager at Esplora Interactive Science Centre in Malta)
- j. Dan Marwit (Senior Content Developer at Moey Inc., in Brooklyn, New York)
- k. David Jones (Community Liaison Manager at the International Centre for Life in the United Kingdom)

Interview themes:

- Interviewees (parents, researchers, neurodiverse individuals) wanted to make it clear that autism is a very large spectrum and designing environments for autistic people depending on where someone is on the spectrum.
- There is a need for more training for museum educators. Museum staff are not always adequately prepared to work with all demographics.
- People with autism would benefit from knowing what to expect before a museum visit. Some parents or individuals choose not to attend for this reason. A parent may not want to spend the money and then find out the environment is not conducive to the children's enjoyment. Some museums may not be as accessible as some visitors may require. For example, bathrooms may need more than just additional space to be accessible. Some autistic people may benefit from a changing area to help their caretaker or a system to help people in and out of their wheelchair (if comorbid). For others, knowing what to expect may mean an easily accessible Google street view that visitors can scroll around and see all aspects of the environment with labels. The labels can indicate if areas near or inside the museum typically are loud or have bright lights.
- Some visitors need designated areas and clear signage of where they are. For some museums, a designated area may be a specific room to serve as a calming area. If museums cannot do so, they should create sensory maps. This signage will make it clear to visitors where quiet spaces, active spaces, and other environments are so they are easy to navigate. Also, where visitors can check out things like sensory bags which include noise-canceling headphones/"ear defenders," fidget spinners, bubbles, and more.

- Autistic visitors need organization and may benefit from a visual schedule. These are typically used in school and at home and share an agenda or plan in a clear visual way. The visual schedule is held in a binder full of pictures with velcro. The agenda has blank spaces to identify in which order throughout the museum visitors will make stops.
- Make sure to frame messages to guests in a way that invites everyone to engage in systems that support everyone of all abilities. Such messaging helps to avoid othering.
- Consider multiple means of interaction: Do the exhibits have ways to adapt to different sensory experiences? Can visitors turn off flashing lights or lower the volume? If not, are there ways that visitors can interact with the exhibit differently?

Description of potential users, their backgrounds, behavior patterns, attitudes, aptitudes, goals, tools they use and environments they work in, current challenges

Although the application would be primarily designed for individuals with autism, the application would serve to benefit many users of all (dis)abilities. Users span across all age groups (with the assistance of a parent, guardian, or caretaker, if necessary). Museum visitors must have a smartphone or tablet device that can utilize a network connection via wifi or data. The user should also be familiar with how to operate the device. People with autism tend to be on a spectrum of various preferences as they relate to noises, lighting, and other environmental factors. If the surroundings do not match the visitor's preference, the individual may react loudly depending on their verbal behavior. In general, as shared from an interviewee, there is a high level of interest in museums and technology by autistic people as museums share a great deal of information on a niche topic, and technology is the tool that allows the information to be explored. A potential challenge is an exhibit that seems very engaging to some visitors may be overstimulating to an autistic visitor. Similarly, when planning which exhibits to visit, the user may be overwhelmed with options in a new, unfamiliar environment.

2. User Modeling

2a. User models (Personas):

James: autistic child, Erie, PA



Background:

James is seven years old and attends the second grade. He has been diagnosed with high-functioning autism and is medicated. James lives with his mom (Janine), grandma (Carlita), and his older sister, Jess, who is age 13 and not autistic. In recent years, the two of them have started quarreling frequently and it is a source of stress in the household. James' father passed away when he was an infant and Janine has never remarried. He is big for his age, likes to play outside, and talks frequently about the RV trips that he has taken with his family as well as the trips he hopes to take in the future. James is curious and seems to really crave knowledge. He has a special interest in entomology and has above-average reading and math skills. Loud noises and unexpected transitions are a source of significant distress for him.



Gym is his favorite class at school. His homeroom teacher, Ms. Carter, speaks very highly of him and says that he is very sweet and helpful. Skills that she wants him to work on include socializing with other students, holding questions for appropriate times, and a better understanding of social cues. James also needs frequent reminders so that he doesn't, for instance, leave his backpack behind. This is a significant improvement over the last two years, however, when he was still adjusting to the school environment and had teachers that Janine feels "didn't really get him."



Context:

James recently went on his first school field trip to a local museum of science and industry. Janine had some hesitation initially about whether the trip would be a good idea for him, but was able to consult with Ms. Carter and was convinced that they could make it work. James can be anxious about new experiences, but with some advance planning, Janine was able to answer some critical questions ahead of time for James, among them, where the bathrooms and “quiet places” were located and where he would be able to eat his lunch. Ms. Carter also has an experienced classroom aide who has taken an interest in James and was able to attend the field trip with the class. There were a few bumpy moments in the day, particularly around some exhibits that made James uncomfortable and a few unpleasant interactions with fellow students, but those were quickly forgotten and Janine was incredibly happy at the end of the day when James came home excited to tell her all about everything he’d learned at the museum and his new interest in aviation. Janine and Ms. Carter also agreed to a debrief on how the trip went and Ms. Carter made a note to herself on some suggestions for museum staff on how the venue could be more accommodating to students like James.

Emmie: autistic adult, Austin, TX



Background:

Emmie is 38 years old, newly married to her partner Leticia, and has 3 dogs. Emmie is a human resources manager for a healthcare firm. She has worked for the same company since college, working her way up from an entry-level position. Joining management has led her to move for work approximately every 3-4 years. However, since meeting her partner online 2.5 years ago, she has married, bought a house, and become a co-parent to her partner's dogs, and Emmie would very much like to settle down in her current community. Emmie describes herself as an introverted "tomboy," she likes country music and enjoys outdoor activities, whether camping or hiking with the dogs or even just having a bonfire in the backyard.



Emmie has not disclosed her status as an autistic person to her workplace with the exception of an older mentor that she met early on during her time with the firm. Emmie is excellent at her job, exhibiting a strong work ethic, keen intelligence, and attention to detail. Some people who do not know her very well are surprised to learn of her success as an autistic adult in her particular field of work. Emmie attributes her success to a very accommodating and supportive corporate climate and strong familiarity with the company's mission and procedures after nearly 20 years of working there. Her comfort in the work environment has actually increased

since achieving management status and she feels that she is in a “sweet spot” right now with the company, not really desiring to climb the ranks of management much higher and pretty satisfied with her current position, level of challenge, pay/benefits, and work-life balance.



Emmie’s partner Leticia is 34-years-old and works in retail. Unlike Emmie, Leticia is an Austin native and loves living there. Leticia is significantly more extroverted than Emmie and has a large friend group from work and her childhood that she likes to spend time with. While Leticia is understanding of Emmie’s feelings of awkwardness and aversion to social situations, she often nudges her to accompany her on weekend outings such as brunches, festivals, and pop-up markets. Leticia’s friends seem to genuinely like Emmie and enjoy it when she joins them, finding the couple to be a fun contrast.



Context:

Recently, Emmie accompanied Leticia and some friends to a festival of film shorts that featured the work of one of Leticia's friends from college. Such outings are not uncommon in Emmie and Leticia's relationship, and can sometimes be a source of anxiety for Emmie. The idea to visit the festival was fairly spontaneous, coming up at brunch that same day. With very little preparation, Emmie did not know what to expect and found the crowds and all of the spectacle and rapid transitions of the festival to be a bit overwhelming. She thinks that she might have enjoyed herself more if she had had more preparation and could have planned the visit a bit more in advance. Additionally, she found some of the film styles to be jarring and difficult to watch and probably would have avoided some of the shorts if she had known more about them beforehand. There was one short in particular, however, that Emmie felt very drawn to—about environmental issues and the impacts of climate change in Alaska—and she would have liked to learn more about the film and the filmmaker than what was available at the festival.

Samantha: parent of autistic children, Tampa, FL



Background:

Samantha is a 29-year-old mother of four. Samantha and her siblings were adopted by a prosperous family when she was still an infant. Her older brother, Scott, committed suicide when they were teens and it profoundly impacted her life. Her oldest boy (age 7) is named after her brother. Both Scott and his six-year-old brother Tommy have been diagnosed with autism. Samantha also has twin infants. Samantha's husband, Brian, is a corporate trainer and travels frequently for work. She sometimes relies on her extended family and friends from church to help with the kids when Brian is away. Prior to having the twins, Samantha was a middle school teacher. She is very interested in infusing technology into the classroom and hopes to return to teaching in a few more years. She spends her scant sparetime reading and listening to podcasts about financial strategies to help her family get ahead.



For now, she mostly has her hands full with the infants and with her two sons, who have struggled in their first few years of school. Both Scott and Tommy are diagnosed with autism and ADHD and have recently started new medication regimens. Before medication, both boys had a very difficult time sitting still and concentrating in class, and both were routinely disciplined for disrupting class with inappropriate speech and/or noises. Scott has adjusted better between the two of them. The medication has “really chilled him out,” according to Samantha. Though his speech and demeanor are much slower now, what Samantha refers to as “zombie mode,” she observes that he is actually higher functioning now overall. His reading and writing skills, in particular, have improved. Tommy continues to have a lot of the same difficulties, however. He absolutely cannot sit still for lessons but does better when he is engaged in hands-on activities such as Lego, drawing, and Play-Doh. Tommy wants to be a “monsterologist” when he grows up and obsesses about all manner of fantastical beasts.



Both the boys love electronics and Samantha fosters this enthusiasm, hoping to employ educational technologies to help the boys get ahead and also using access to their electronics as a reward-punishment system to manage their behaviors. Due in part to her upbringing in a military family, Samantha has adopted a strict parenting style. Particularly given her background in education, Samantha holds her children, and her children's teachers, to high standards. As a stay-at-home mom, she gets daily report-backs from the teachers and regiments each evening according to the day's behaviors.



Context:

Now that she is at home and is able to handle domestic affairs during the week, Samantha would like to spend time on the weekends engaging her boys in some enriching activities that they might not have access to in school. Thus far they have enjoyed local parks, but particularly as the weather warms up, she wants to find some more indoor activities that they can explore. There are a lot of local zoos, children's museums, and regular events that she thinks the boys would really benefit from, but she needs to be able to plan ahead with these visits during the week. The better planned the trips are, the better prepared the boys will be and the less time she'll have to spend managing behavior. In addition, she hopes to involve the brothers in planning each weekend's activities as an incentive for their good behavior in school that week. Samantha could use some help in finding the activities most suited to her children and, even

better, something that will help her gauge their enthusiasm and steer them toward other, similar experiences.

Landon: museum curator, New York City, NY

Background:

Landon is 52 year old and works as the senior education director in the exhibits and public programs department of the American Museum of Natural History in New York City. He is the only one that serves in this role. Part of his responsibility includes overseeing a team of eight education coordinators and 3 volunteers within the museum.

Landon had a childhood vision of being a classroom teacher. After graduating cum laude from Binghamton University, he began teaching high school biology. At the age of 27, Landon and his wife decided to start a family. Once their daughter was born, he found the demands of being in a K-12 classroom to be too much of a burden and decided to search for a new role that would allow him to be more present with his family outside of work hours. Today, Landon is the father of two daughters and one golden retriever puppy. In his free time, Landon enjoys learning about archeology and visiting dig sites when he can. More specifically, he has taken up the hobby of flint knapping with others. This pastime has allowed Landon to meet others and brainstorm concepts that would work well in upcoming exhibits. It has also opened his eyes to how different individuals access information in a way that makes the most sense to them. The moments of learning from others have served to be transformational and inspiring for Landon to make sure his museum work is accessible to everyone. Currently, Landon makes an effort to host focus groups and informal interviews with people of all abilities to make sure upcoming exhibits best serve to enhance their experience.

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