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Interactive Learning with Plankton

Constructing Kiosks for the SEA Discovery Center

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Abstract

This project involved creating two interactive kiosks for the SEA Discovery Center to better engage visitors on their plankton exhibits. HTML, CSS, and ReactJS were used to construct web apps that could be launched in Chromium’s Kiosk Mode upon system boot time so that the application would automatically run, preventing visitors to the Center from gaining access to the computer beyond the main program. They are hosted externally on Western Washington University’s Cyber Range and are run on the kiosk machine by Raspberry Pi 4s that access it via a URL. The informational kiosk was designed to give visitors an overview of plankton and their lifecycles while the game offers a more in-depth interactive aspect to the plankton exhibit. The ultimate goal of both of these kiosks is to further connect visitors with and deepen their knowledge of the plankton exhibit through user-interactive displays.

Business Requirements

Background

The SEA Discovery Center is a nonprofit organization whose main project is to oversee the aquarium on the Western Washington University campus in Poulsbo. Its purpose is to connect the community to the animals, habitats, and people from across the region by informing the community of the ecology of the Salish Sea. The goal of this project was to create an informational and game kiosk for the SEA Discovery Center to provide detailed information and an engaging game element for the exhibits without requiring additional effort from SEA Discovery Center employees. To fulfill this need, an informational and game kiosk were constructed to provide information about the plankton exhibit at the Center. These kiosks give visitors a deeper understanding of plankton’s ecological role and life cycle and the minigame provides a more in-depth interactive and educational aspect to the plankton exhibit. These two kiosks, through the use of intriguing designs and user-interactive elements, encourage visitor interest in the SEA Discovery Center’s plankton exhibit.

The current industry encompasses a wide range of interactive and informative displays, and in recent years digital kiosks have become more and more common in museums, visitor centers, and other educational institutions. Some kiosks are purely informational, simply displaying further information about an exhibit with different pages a visitor can tap through. Others take a more active role, employing mini-games, quizzes, and other user-interactive elements to engage visitors. Kiosk software is available on the market, in the form of products provided by companies like UView, Kioware, and SiteKiosk. These products, however, can be several hundred dollars per year, which is more than the SEA Discovery Center is willing to spend. Furthermore, creating custom software gives the SEA Discovery Center complete control over the kiosks’ looks, designs, and features. The purchase of third-party software would come with potential restrictions in that the Center would have to follow the design guidelines as limited by the software. Especially concerning user interactions, the Center would have to rely on whatever functions are built into the purchased software instead of having the freedom to commission specific, custom features.

Business Opportunity

The SEA Discovery Center required additional ways for visitors to interact with and learn about their aquarium exhibits. Informational and interactive kiosks ensure customers have a more impactful experience at the SEA Discovery Center as they deepen their knowledge of the Salish Sea and its inhabitants. The addition of a game kiosk also provides a more in-depth level of engagement and internalization of knowledge about the exhibits. By adding these kiosks, the Center more effectively guides visitors through the learning process involved with their exhibits and engages with visitors on a higher level.

From an industrial standpoint, the addition of our kiosks will excite interest in the SEA Discovery Center and potentially bring more visitors to its doors. Furthermore, it will advance the Center’s goal of filling an educational role for its visitors, allowing them to fully enjoy their visit while they expand their knowledge.
Business Objectives and Success Criteria

The main objective of our kiosks is to increase visitors’ knowledge about the plankton exhibited at the SEA Discovery Center. Previously, the SEA Discovery Center lacked comprehensive displays that were constructed to inform visitors about the exhibits. Although the exhibits themselves are points of interest, they provided only surface-level information and lacked the nuance and expertise of knowledge that can be conveyed by a person with a deeper understanding. Our kiosks bridge this gap and introduce visitors to a more in-depth understanding of aquarium subjects. The game kiosk also ensures visitor satisfaction through its interactive features, broadening their learning environment. Moreover, the addition of the kiosks reduces the burden on the SEA Discovery Center’s workers since employees do not have to be present at exhibitions for explanations.

We hope the introduction of these kiosks will garner more interest in the SEA Discovery Center. We can gauge this by if there is a significant increase in visitations to the Center after the installation of the kiosks. These kiosks also aim to bring attention to specific exhibits in the SEA Discovery Center and will inspire visitors to attain a deeper understanding. One way we can test the success of these objectives is by conducting a user survey. Questions may include:

- What was your favorite page and why?
- What was your least favorite page and why?
- What did you find particularly interesting about the information presented?
- Was there any information you felt was poorly conveyed?
- Were there any pages that seemed unnecessarily convoluted?
- What are your thoughts on the interactive aspects of the kiosks?
- What are your thoughts on the general design of the kiosks?

We can also evaluate our kiosks’ designs by using heuristic evaluation. That is, we can analyze each of the kiosks’ program structure and whether it satisfies the evaluation criteria of simple and natural dialogue, widely recognized symbol and language patterns, minimizing user memory load, consistency, system feedback, clearly marked exits and pathways, descriptive error messages, and error prevention.

Customer and Market Needs

The SEA Discovery Center requires customers to have these kiosks so they can better convey information about their exhibits in an engaging way. Additionally, these kiosks allow the Center to educate visitors about the exhibits efficiently, while also providing an interesting visual element. The Center also needs these two kiosks because, as the aquarium was structured, it had very few additional exhibit supplements to inform visitors about its animals. This means that visitors may not have been adequately informed about the various specimens at the aquarium, and our kiosks were built to fill this gap. Through these kiosks, the SEA Discovery Center can spread knowledge and awareness about its exhibitions while also adding more options for visitor engagement.

Business Risks

The most concerning risk of this project was addressing visitors’ ability to tamper with the kiosk and its program. Users should not be able to access the control panel buttons of the kiosks, especially the power button since visitors could turn the kiosks off and potentially gain access to the computer. If a malicious visitor were to gain access to the main Raspberry Pi, this could prove disastrous as they could open the command line and even write malicious code. This is somewhat mitigated by the fact that we will be ensuring the kiosk programs will boot at runtime, but, if the user was able to bypass or disable this, we encounter the same issue. Therefore, it will be necessary to conceal the buttons from visitors or they must be placed such that a visitor does not have access to them. The kiosk selected by the SEA Discovery Center has these buttons in easy reach, so they will likely need to be
either camouflaged or have some sort of cover placed over the top of the buttons such that they can not be easily pressed. Similarly, the wiring and Raspberry Pi will be exposed on the back of the kiosk, so this area will also need some sort of covering. However, even if an attacker were able to gain access to the Pi, our applications will be hosted externally on WWU’s Cyber Range, so, if the Pis are wiped or otherwise corrupted, the kiosk should be easily restored by following the steps outlined in the documentation. The applications will even still be accessible via their URL links and will not suffer any corruption that occurs on the Pi.

Another risk is concerning the environment surrounding the kiosks. Since the kiosks will be placed in an aquarium with a touch pool, they must be protected from water damage. Wiping the screen down once a day with a microfiber cloth and cleaning solution should be a sufficient measure to prevent potential grime buildup or damage. Another waterproofing solution would be to cover the screen with waterproof films so that the actual machine would not be affected by the water. The Raspberry Pi should also be placed or protected such that it will not come into contact with water.

Vision of the Solution

Vision Statement

For the SEA Discovery Center, which required a way to efficiently and interestingly convey information about its exhibits, we created informational and game kiosks. Unlike current kiosk software, our kiosk design was tailored to the Center’s specifications and came at a much cheaper cost.

Major Features

The informational kiosk was designed to provide introductory information about pluteus, ephyra, nauplii, and veliger plankton and their respective adult forms, sea urchins, jellyfish, barnacles, and mussels. The first page simply shows the title “Drifters: Plankton in Liberty Bay” and prompts the user to tap the screen. Tapping the screen leads the user to the index page, where they can select between circle icons that each display an image of a plankton labeled with its name. Tapping a plankton’s icon will bring the user to its respective page that displays facts about the plankton and its adult form. The user can then tap the button labeled “Back” to navigate back to the index page and select one of the other plankton icons and view their page. After a minute of inactivity, the kiosk will be automatically reset back to the main resting title page.
First page of the informational kiosk. Title reads “Drifters: Plankton in Liberty Bay” and it prompts the user to tap the screen.

Second page of the informational kiosk. Four plankton icons are shown and the user is prompted to tap on one.
**SEA URCHIN**

*Pluteus* is a planktonic larval stage of the genus *Strongylocentrotus*: sea urchins!

Sea urchin page that appears after tapping on the pluteus icon. Tapping Back will take the user to the index page.

**MOON JELLY**

Moon jellies have a complex life cycle. After the sedentary polyp stage, nearly microscopic ephyra “pop” off and become free-swimming.

Jellyfish page that appears after tapping on the ephyra icon. Tapping Back will take the user to the index page.
The game kiosk is designed to be played after viewing the informational kiosk, although it also serves to further educate the user in addition to encouraging them to use what they learned from the informational kiosk. The game kiosk’s main page is similar to the index page of the informational kiosk; three plankton icons corresponding to pluteus, ephyra, nauplii, and veliger plankton are displayed. Tapping one brings the user to the main game page, where five phytoplankton icons are randomly generated across the screen with the selected plankton icon in the middle. The user is prompted to tap on the phytoplankton icons, and doing so will generate a fact about the plankton at the bottom of the screen. Once the user has tapped on all five of the icons, they are prompted to tap on the plankton. Tapping on it will give a final fact about the plankton’s adult form and transform the icon into an icon of this form. The game kiosk also has a back button that allows the user to exit the game at any time and return to the
main page where they can select any of the other plankton icons. Similar to the informational kiosk, the game kiosk also has a timer that resets it to the main page after a minute of inactivity.

![Image of a plankton selection screen]

*First page of the game kiosk. The user is prompted to select one of the four plankton.*

![Image of a plankton feeding screen]

*Second and main game page of the game kiosk. Once a plankton is selected five phytoplankton icons are generated and the user is prompted to tap on them.*
Feed the plankton by tapping on the phytoplankton!

Pluteus plankton are calcareous, meaning their shells contain calcite, a soft mineral that dissolves in weak acid!

Tapping on a phytoplankton causes a fact about the plankton to appear.

Tap on your plankton!

Pluteus plankton are a type of larva - they grow into sea urchins!

After tapping on all the phytoplankton icons, the user is prompted to tap on the plankton.
Assumptions and Dependencies

The selected Dell 24 Touch Monitors have all of the necessary ports to display our applications using the Raspberry Pi and have touchscreen functionality, but their power buttons are within easy reach of users. These exposed buttons are vulnerable to malicious behavior and tampering could cause the kiosks to malfunction. We are assuming that the SEA Discovery Center will take the necessary steps to prevent this behavior by installing a covering or some other preventative measure.

Our kiosks have been designed to be scalable and able to work on a variety of large screen sizes, but it was assumed the kiosk application would not be displayed on a screen size comparable to a phone or smaller. At such a small dimension, component sizes glitch and fail to fit the screen well. However, given the scope of this project, it was assumed that fitting the application to such small screen sizes was unnecessary.

Since our program is hosted externally on the Cyber Range’s servers, it is assumed that the Pis running the applications will always have access to the Internet so that they can connect to these servers.

Scope and Limitations

Scope of Initial Release

The scope of our initial release consists of two functioning kiosks. One displays information that educates the visitors of the SEA Discovery Center about plankton. This includes general overview information about plankton and descriptions of a plankton's life cycle stages. It also includes a design that aligns with the Center’s overall design themes. The other has an interactive mini-game where the user can select a plankton sprite and tap food icons that generate a fact about that plankton. After the food is consumed, the user can tap on the plankton icon
to generate a final fact about its adult stage. The initial release also includes support for touch-screen interaction; users can touch on an image or button that leads them to a new informational screen, select a plankton avatar, and tap icons to generate facts.

Scope of Subsequent Releases

Currently, there is sufficient demand for two additional kiosks that are out of scope for this project. One is a kiosk that displays information about the water quality, but this idea is still significantly nebulous since the sponsors have outsourced the information gathering to another group at Western Washington University and have yet to receive the finished product. The second is a kiosk targeted towards kids and would display general information about the Salish Sea. It would also include an educational mini-game as a way for the SEA Discovery Center to connect further with children. There was also the idea for a QR code that would link visitors to a website or digitized version of a pamphlet the Center distributes. In our initial release, all art and sprites are 2D, but 3D modeling could be introduced in subsequent releases. An additional GUI and interface could also be added if the client wishes to alter the design of the program in a significant way, including changing background images, adding pages, etc, but we will not be developing this at this time.

Limitations and Exclusions

Website creation or form digitization is entirely out of scope of this project, so, as in the case of the QR code in a potential subsequent release, we assume it would link to a preexisting website. Any form of audio content has also been excluded from this project because our kiosks will be located in a public place where it may be too loud to hear or disruptive to the atmosphere of the Center. This could potentially be remedied with the use of headphones, but, at this time, there is no exceptional need to justify the purchase and implementation of this equipment. There has also been the suggestion of implementing external controllers, but this has been excluded for two main reasons. The first is that external controllers are much more prone to wear and tear and may require more upkeep or replacement than is desirable. The second is that the kiosk design is to be simple and easy to navigate, and more complex features that require the use of external controllers run the risk of distracting visitors from the aquarium itself or of losing visitors’ interest. This same attitude may carry over in designing mini-games; the games should be simple and short, but still able to capture adequate attention while also being informative. Client modification of the program's design will also be limited; if the client wishes to completely alter the program's look, they will need to construct and install an entirely new program since we will not be supporting extensive client modification.

Business Context

Stakeholder Profiles

Bridget Anderson: Director of Operations and Outreach
Kelly Bushnell: Educational Specialist
Emily Bjornsgard: Aquarium Curator

Team
Omar Hammou: Communications director between team and sponsors, Programmer

Suhyun Ban: Lead Programmer

Sierra Schuster: Project Manager, Programmer

Rachel Knapp: Security Expert

The four stakeholders above wished for the kiosks to be added to enhance visitor engagement with the exhibits and provide in-depth information about them. The hope for these stakeholders is that by adding these kiosks they will be better able to connect visitors with the Salish Sea

Clientele: Individuals of all ages

The kiosks have the potential to be viewed by individuals of all ages. As a result, kiosk designs had to be engaging to adults while also simple enough that children could interact with and learn from them.

Project Priorities

The priority of this project was to have two fully functional kiosks installed at the SEA Discovery Center. The informational kiosk was constructed according to the designs of the SEA Discovery Center and the game was built to complement this informational kiosk and further engage visitors on the plankton exhibit.

Operating Environment

The products are used to enhance and educate the SEA Discovery Center visitors on the plankton exhibit. The kiosks will also be placed strategically such that they won’t get in the way of the visitors while still being obvious and eye-catching. This will help avoid visitors tripping over the equipment and avoid any safety liability while still allowing the kiosks’ content to be viewed easily. Strategic placing can also ensure that the kiosks are not in danger of being damaged by water.

Scheduling

Gantt Chart
Development

Quarter 1 - Sep 29 - Dec 9

Our first step for this project was to research kiosk construction and how we could go about creating a kiosk application from scratch. We decided the applications would be hosted on a web browser, and decided on Chromium because it is an open-source browser developed by Google and has a specific mode called “Kiosk Mode” that displays an application in full screen, blocking access to the rest of the computer. We also decided at this time to run the applications on Raspberry Pi 4s since the Raspberry Pi computers are small and portable and therefore can be easily attached to whatever kiosk the SEA Discovery Center purchased. Raspberry Pis are also good computers for single-task applications and have a customizable OS. We could then alter the Raspbian OS in any way necessary for the kiosk application to be launched upon boot time in Chromium. In these beginning months, we planned to construct the kiosk in HTML and CSS and began designing the informational kiosk accordingly. These designs, however, were abandoned in favor of designs provided by the SEA Discovery Center in the form of short video files. We attempted to simply embed these videos using HTML but discovered it is not possible to stretch videos to fit a screen, prompting us to begin to recreate the designs digitally. The script to boot an HTML page on runtime in Chromium’s Kiosk Mode was successfully written at the end of this quarter.
Slide 1 of designs provided by the SEA Discovery Center. Title says “Drifters: Plankton in Liberty Bay” and it prompts the user to tap the screen.

Slide 2 of designs provided by the SEA Discovery Center. Reads “Some plankton are larvae: juvenile forms of common marine life.” and prompts the user to tap on one of four plankton icons.
Slide 3 of designs provided by SEA Discovery Center. Shows a fact about pluteus plankton and its adult stage, sea urchins. There is also a back button meant to navigate back to slide 2.

Slide 4 of designs provided by SEA Discovery Center. Shows facts about ephyra plankton and its adult stage, jellyfish. There is also a back button meant to navigate back to slide 2.
Slide 5 of designs provided by SEA Discovery Center. Shows facts about nauplii plankton and its adult stage, barnacles. There is also a back button meant to navigate back to slide 2.

Slide 6 of designs provided by SEA Discovery Center. Shows facts about veliger plankton and its adult stage, mussels. There is also a back button meant to navigate back to slide 2.

Quarter 2 - Jan 4 - Mar 17

After the discovery that videos could not be stretched in HTML, we began to develop the informational kiosk by copying the designs given to us by the SEA Discovery Center. Although we still used HTML and CSS, we
also implemented the JS library, ReactJS, to achieve dynamic web pages. We also ensured that the pages could be resized to fit any kiosk screen the SEA Discovery Center might choose. We designed the informational kiosk to mimic the Center’s designs as closely as possible, and they are extremely similar except for that we were not given access to the exact images used. Instead, we sourced from images available to the public. Most of this quarter was focused on the informational kiosk’s development, and it was very near completion by the end.

Quarter 3 - Mar 28 - Jun 9

Wrapping up the informational kiosk, we discovered that the application could not be launched in the same way as before our shift to ReactJS, so the script had to be rewritten. It was also discovered that wait times between page loading were long and that background videos had long periods of buffering, so the decision to host the applications externally was made. Originally, the applications were hosted on AWS, but, after denial from the Center to host with Amazon, it was moved to WWU’s Cyber Range. Game development also took place throughout this quarter, but, as a result of many of the complications above, construction was somewhat rushed and many features were cut in favor of having a fully functional product.

Individual Responsibilities

To best divide the responsibilities of this project, we assigned leadership roles amongst the different team members concerning its different parts. Sierra Schuster was in charge of scheduling and general project management, which involved ensuring the team was following our proposed schedule, ensuring items were turned in on time, and structuring how we approached this project. She was also one of the major programmers for this project alongside Suhyun Ban, coding the front page, sea urchin, and mussel page of the information kiosk and the game kiosk. Suhyun headed the setup of the kiosk, which entailed downloading Chromium onto the Raspberry Pi and configuring it to run the web applications on startup and in Kiosk Mode. Additionally, he coded the index page and barnacle page of the informational kiosk as well as helped refine the minigame. Rachel Knapp headed security risk analysis of the Raspberry Pi and kiosk programs alongside the help of Omar. Additionally, Omar was also in charge of communications with the client since he was located in Poulsbo near the SEA Discovery Center. Omar also helped code the Jellyfish informational page. Although we all participated and helped each other with the different aspects of the project, the outline above gives the major responsibilities of each project member.

Deliverables

Software / Hardware

Two fully functional kiosk applications constructed using HTML, CSS, and ReactJS were completed. These applications were then hosted externally on WWU’s Cyber Range. Modifying the Raspbian OS allowed the Raspberry Pis to access the applications via a URL and launch them in Chromium’s Kiosk Mode on boot time. The Raspberry Pis were then wired into the kiosks bought by the SEA Discovery Center.

Documentation

Firstly, our documentation includes how we set up the kiosks and the Raspberry Pis connected to them. This includes how we downloaded Chromium to run our web applications on startup in Kiosk Mode. Secondly, we have documentation of the web applications, detailing their general structure, how different files and programs interact, and how the code itself works.
Acknowledgments

This project would not have been possible without the work of Suhyun Ban, Omar Hammou, and Rachel Knapp as outlined in Individual Responsibilities. Without their contributions, this project certainly wouldn’t have been able to see completion. Dr. Justice Banson of WWU’s CS Department also provided us with invaluable advice and feedback on how to handle challenging errors we came across. Paul Haithcock set up the applications on WWU’s Cyber Range and was extremely helpful by showing us how to get everything working and how to navigate the Cyber Range. Finally, Piper Wolters helped us throughout the entire process as our advisor and gave us her steadfast support.