Celebrating 30 Years of the Venice Project Center

Venice, B18

30th Anniversary Team

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Abstract

In the 30 years since its founding, the Venice Project Center (VPC) has collected and analyzed a vast amount of data on a variety of subjects about Venice. Our team's mission was to celebrate the 30th anniversary by furthering the Venice Project Center's goal of publishing data in accessible formats and providing it to anyone interested in Venetian culture. Our team focused on ways to do this both digitally, such as through the new VPC 3.0 Website, and in print through a booklet series: "Knowing Venice." The most notable deliverable is the redesign of the Sandbox application, which can be used to turn the Venice Project Center's data into informative data visualizations. Each of our deliverables contribute to the VPC's mission of making its decades of work open to all.

Executive Summary

The Venice Project Center (VPC), founded in 1988 by Fabio Carrera, is celebrating its 30th anniversary this year. The Venice Project Center was established with the mission of "leaving Venice better than we found it" and has hosted over 750 students to accomplish this. These students have worked on over 200 projects that were primarily focused on collecting data and creating modern solutions to age-old issues confronting the city. To help overcome these problems, the VPC started an open data initiative to make both the data and solutions more accessible to the public.

As the 30th Anniversary team, our goal was to ensure that the data and impacts of the VPC were well publicized and easily accessible to the public. Over the past 30 years, the VPC has made a significant impact on the city of Venice. Our team researched and summarized these impacts, and posted them on the newly designed VPC 3.0 website (Figure I). The user can select a topic, such as the proposed cargo delivery system, and will be brought to a webpage with a short paragraph summarizing that accomplishment.
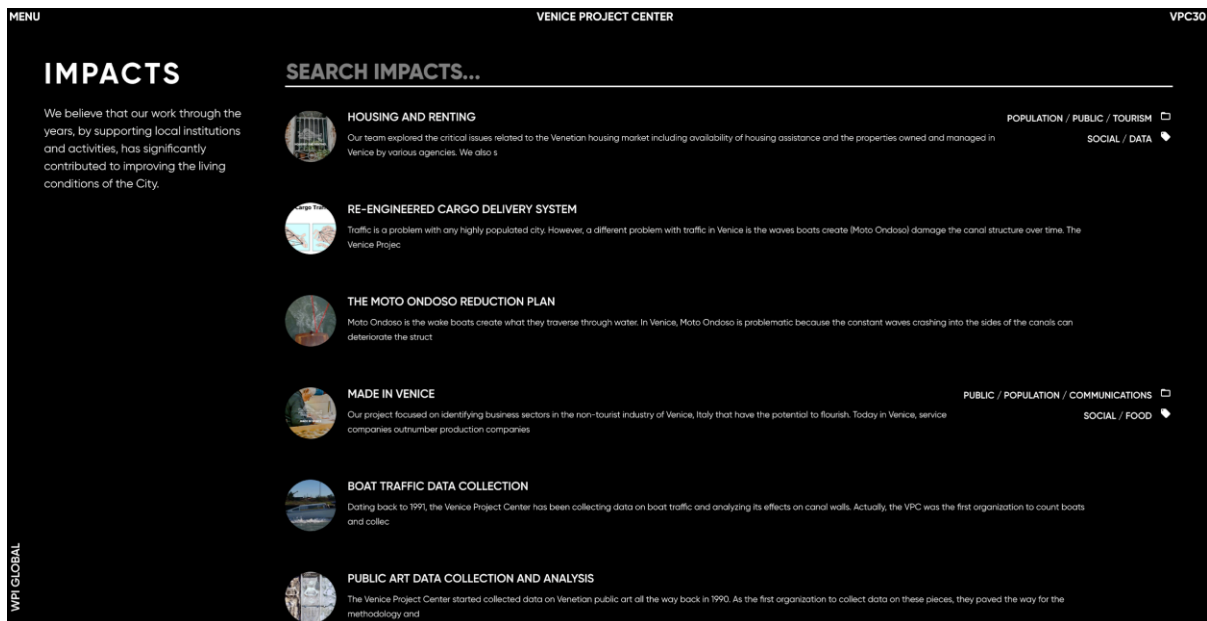

Figure I - Impacts Page

To encompass 30 years of the VPC's achievements in a single online location, we created an interactive timeline that highlights the Center's most important impacts and milestones (Figure II). The timeline will serve as a synopsis of the VPC's history, and can be put on display at future anniversary events. This application will enable anyone to look back on the impressive accomplishments of the center and will hopefully inspire future VPC teams. In addition to publicizing the VPC's accomplishments online, we helped them further their mission of publishing their research in print.
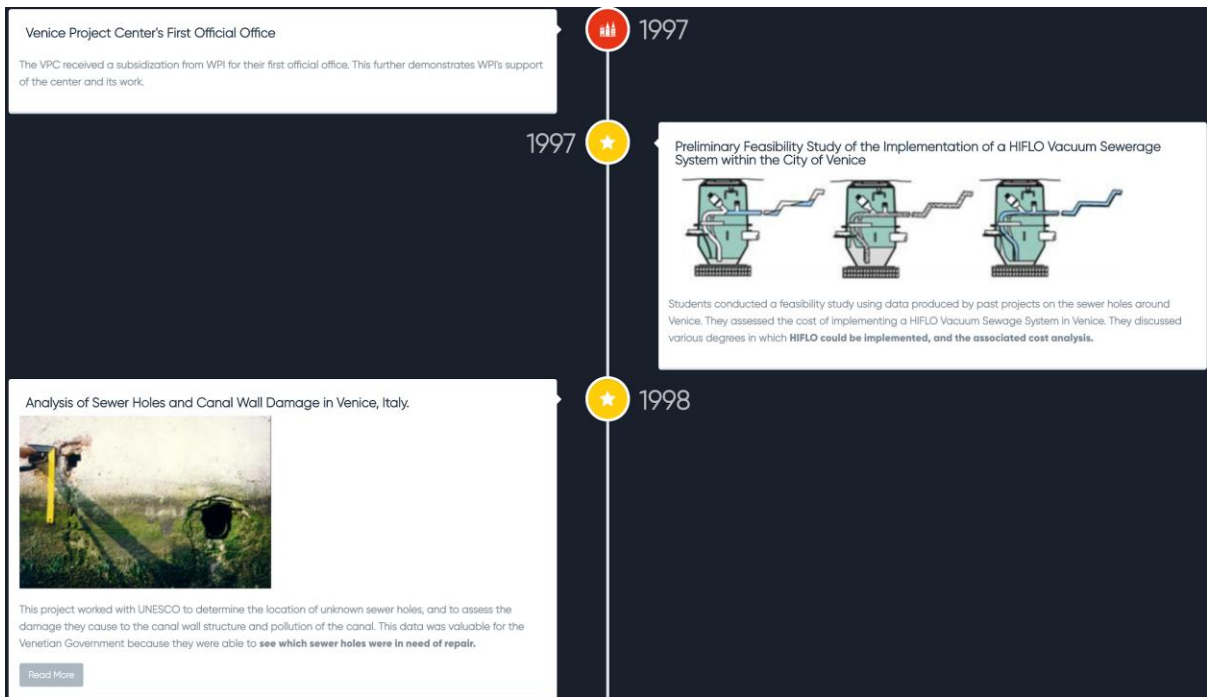
Figure II - Timeline Application

One way the VPC aims to make its data more accessible is by publishing it in a booklet series called "Knowing Venice." The VPC plans to publish thirty of these booklets, with each one covering a different aspect of Venetian culture. The content of these booklets will be supported with infographics and visuals, so we developed Sandbox to assist in creating these visualizations. Sandbox is a tool that allows people without a technical background to create interactive graphs and charts. Our main goal in Sandbox's development was to ensure that it was useable by the VPC for the "Knowing Venice" series. In addition, Sandbox can also be used to assist future teams in their own projects. Sandbox is a powerful tool for the center because it pulls the latest data from the VPC's database, as illustrated in Figure III.
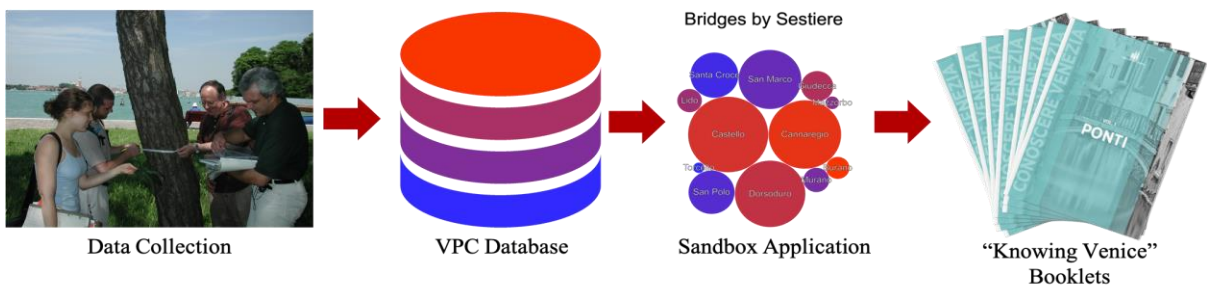

Figure III - Sandbox Workflow

To demonstrate how easy Sandbox is to use, we will walk through the creation of a stacked bar chart. Upon loading the website, the Sandbox home screen (Figure IV) appears, where there is a guide that explains what Sandbox is and how to uses it. Then, the user can select a dataset and graph type to generate a graph, shown in Figure V. Continuing on, the user can add stacked bar graph elements to display additional variables, as well display a legend to show which colors correspond to variables (Figure VI). Lastly, the user can apply a title and custom color palette to the graph, displayed in Figure VII. When the graph is completed, it can be exported and put into a publication, such as a "Knowing Venice" booklet. A mockup of this can be seen in Figure VIII.
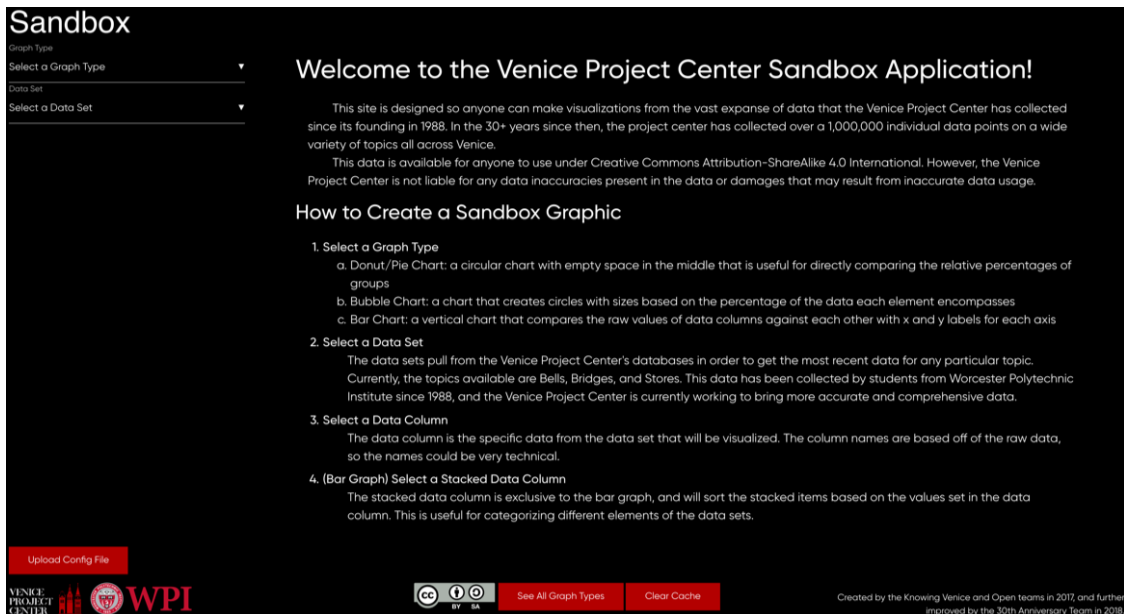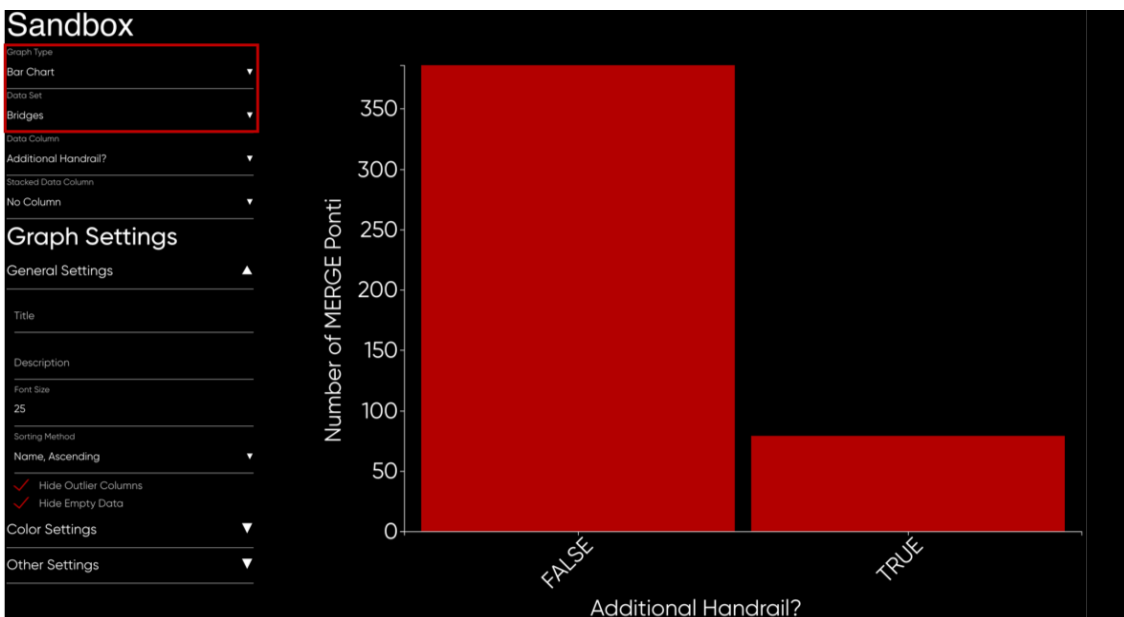

Figure IV - Sandbox Home Page
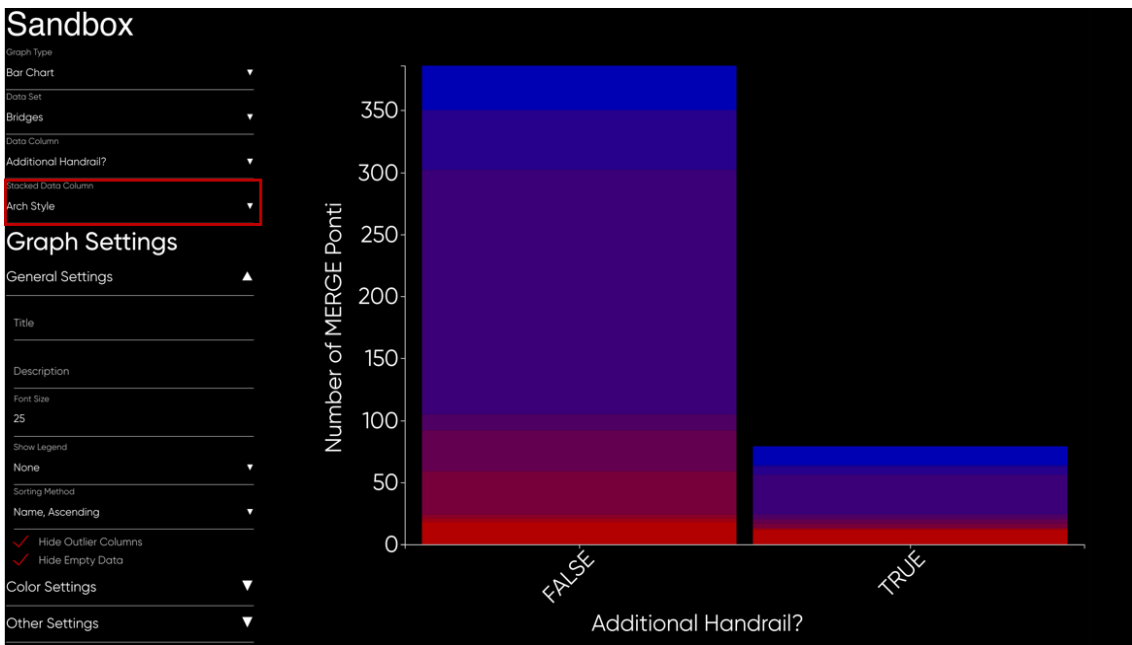

Figure V - Sandbox Step 1

Figure VI - Sandbox Step 2

Figure VII - Sandbox Step 3

Tipologie di Ponte

Arch Style of Bridges with and Without Handrails

- A tutto Sesto
- Irregolare
- Non Rilevabile
- Piano
- Policentrico
- Sesto Acuto
- Sesto Ribassato
- Sesto Super Ribassato
- Sesto super ribassato
- Trapezoidale

Number of MERGE Ponti

350
300
250
200
150
100
50
0

FALSE   TRUE

Additional Handrail?

In tutta la laguna, ivi compresa Venezia e le isole dell'estuario, vi sono XXX ponti, esclusi quelli identificati e discussi nel capitolo precedente. Di questi, XXX sono nella Città Storica (di cui XX alla Giudecca), e XXX nell'estuario.

PONTI PUBBLICI

La stragrande maggioranza dei ponti a Venezia, come pure in Laguna, sono pubblici ed assolvono la loro funzione di collegamento tra isole per tutti i flussi pedonali, sia per residenti che per visitatori. I ponti pubblici in tutta la laguna sono XXX di cui XX nelle isole dell'estuario ed il resto a Venezia (XX) e Giudecca (XX).

PONTI PRIVATI

Una minoranza di ponti serve solo per raggiungere abitazioni private dalle pubbliche vie e sono tipicamente definiti come ponti privati, anche se in verità sono pubblico-privati, in quanto accessibili al pubblico da uno dei due lati, anche se senza sbocco viario dal lato opposto. Alcuni ponti privati sono dotati di cancellate che li rendono privati al 100% anche se questi sbarramenti sono spesso solo simbolici e facilmente valicabili.

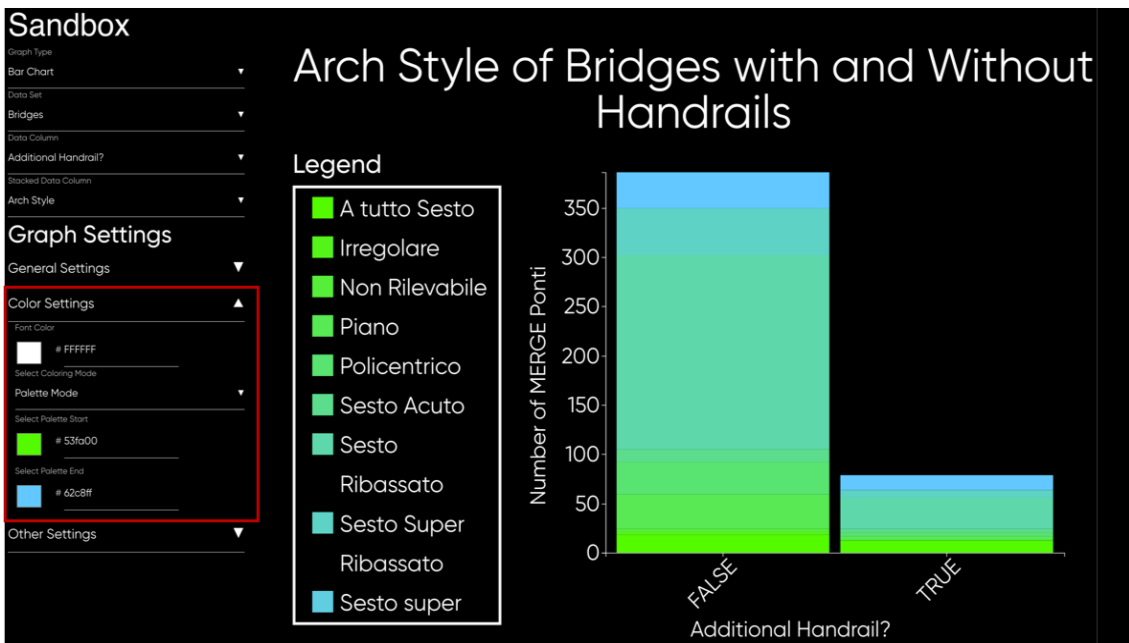In totale, i ponti privati in tutta la Laguna sono XXX, di cui XXX a Venezia e XX alla Giudecca. Nelle isole dell'estuario i ponti privati sono in tutto XXX.

Figure VIII - Published Sandbox Graphic

We are excited to have helped the Venice Project Center celebrate its 30th anniversary. The tools we have developed will help the VPC achieve its initiative of making its data more accessible to the public. Our team recommends that future updates to Sandbox will include more graph types and allow the user to upload custom data sets. This will allow for even more dynamic graphs and charts to be created, both for digital publication and for the "Knowing Venice" series. We hope that future teams continue to help the Venice Project Center make strides towards its mission of "leaving Venice better than we found it."

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Authorship

       The authors of this proposal are Nick Delli Carpini, Elijah Ellis, Samuel Hale, and Kenneth Morton. The work for this project was evenly divided among all team members.

Acknowledgements

1.0 Introduction

In the past 5 years, the amount of data across the world has increased ninefold, with over 2,500 petabytes of data being created daily (Forbes, 2018). However, over 90% of this data is still unstructured (VCloudNews, 2015); it must be visualized for humans to make any use of it. Data visualization is the process that transforms data into understandable graphics and provide context for complicated issues. As data collection becomes more extensive, it becomes increasingly important to have effective tools to make this data useful.

The Venice Project Center (VPC) has seen over 750 students and numerous faculty members contribute to over 200 projects, and has focused on "leaving Venice better than they found it" through data collection and analysis. The VPC has accumulated over one million data points throughout its 30 years of work in the city, and strives to represent this data in the most impactful way possible. Without proper visualizations of the project center's data, potential students and organizations are unable to gain appropriate perspective on the important issues facing the city.

Past teams have attempted to categorize and organize the huge quantity of data collected by the VPC and publish it for public viewing. They have worked on the Sandbox web application and the "Knowing Venice" booklet series. Sandbox uses the data that the Venice Project Center has collected and allows users to create interactive graphs. The "Knowing Venice" series provides an encyclopedia-like method of presenting Venetian data by organizing it into smaller topics. These booklets, in addition to the new VPC 3.0 website, will increase the presence of VPC data both digitally and in print.

While these tools provide a framework, there were significant limitations that prevented them from being effective and user friendly. Sandbox's graphics were sometimes incomprehensible and had poor aesthetic. Also, the tool did not use the VPC's most up-to-date data. Developing these data visualization tools will allow future teams, sponsors, and anyone else who needs it to better interact with VPC data. Furthermore, the VPC needs a way to broadcast the new tools and accomplishments the center has made.

Our goal was to contribute to the celebration of the Venice Project Center's 30th anniversary by developing a tool to create impactful data visualizations that will be accessible to the public, along with other initiatives to publicize the work of the project center. We accomplished this by continuing the development of the Sandbox tool so that future teams can use it to create visualizations of VPC data for the "Knowing Venice" booklets and the new VPC 3.0 Website. Additionally, we created a comprehensive summary of the Venice Project Center's achievements over the past 30 years and used it in both a timeline application and the VPC 3.0 Website. Our team also increased the web presence of the VPC through a series of social media campaigns. Our work throughout the semester was always guided by the overarching mission of "leaving Venice better than we found it."

2.0 Background

Since its founding in 1988, the Venice Project Center has collected a vast amount of data. This data has spans many aspects of Venetian life, and publicizing this data has always been an objective for the VPC. This chapter will outline the past 30 years of VPC projects and impacts in order to understand its influence on both the city of Venice and Worcester Polytechnic Institute (WPI).

2.1 30 Years of VPC History and Impacts

In 1988, Fabio Carrera gathered six WPI students to complete the first project at the VPC, "The Feasibility of a Venice Project Center." A picture of this team can be found in Figure 2.1. Their project determined areas where student groups could improve the city, and they drafted IQP proposals for future teams to base their own projects on (Behmke et al., 1998). In order to assist with their research, the National Council of Research provided the team with a space to work and technology to facilitate their success. This project proved to WPI that there was plenty of valuable work to be completed in Venice, and the university established the VPC as an official IQP center in 1993. This opened the door for hundreds of students to go to Venice in the following years, and teams since then have collected data about everything from canal sediment and hydrodynamics to the preservation of public art.
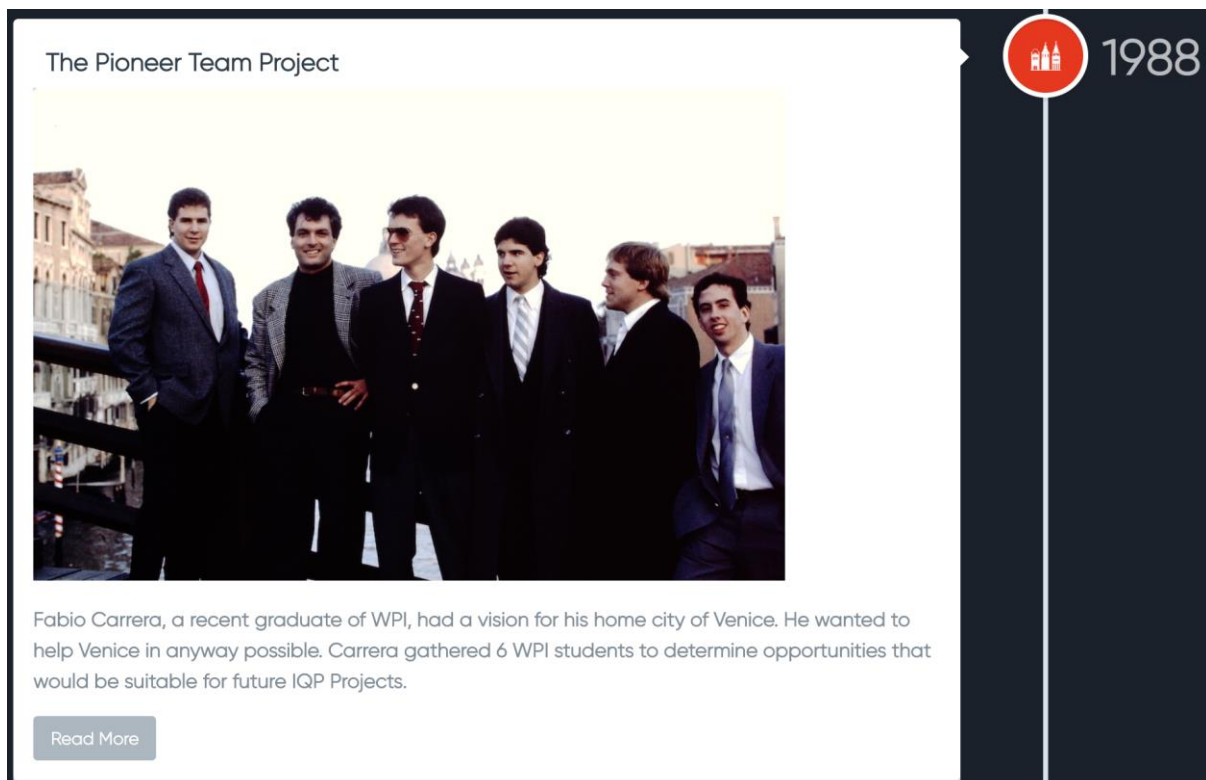

Figure 2.1 - Pioneer Team with Fabio in Timeline Application

Public Art Data Collection and Analysis

1978   1991   2005 "restauro"   2007   2008

The Venice Project Center started collected data on Venetian public art all the way back in 1990. As the first organization to collect data on these pieces, they paved the way for the methodology and data collection techniques necessary to determine aspects such as, location, current appearance, and cost needed to repair. In 1995, these methods were finalized as the VPC won another IQP award for the team's algorithm for cost of restoration. Additionally, their prioritization system they developed was cited in "Technology Review." Since then, the center has been collecting data and public art all around Venice and working with PreserVenice to keep these pieces in good condition for years to come.
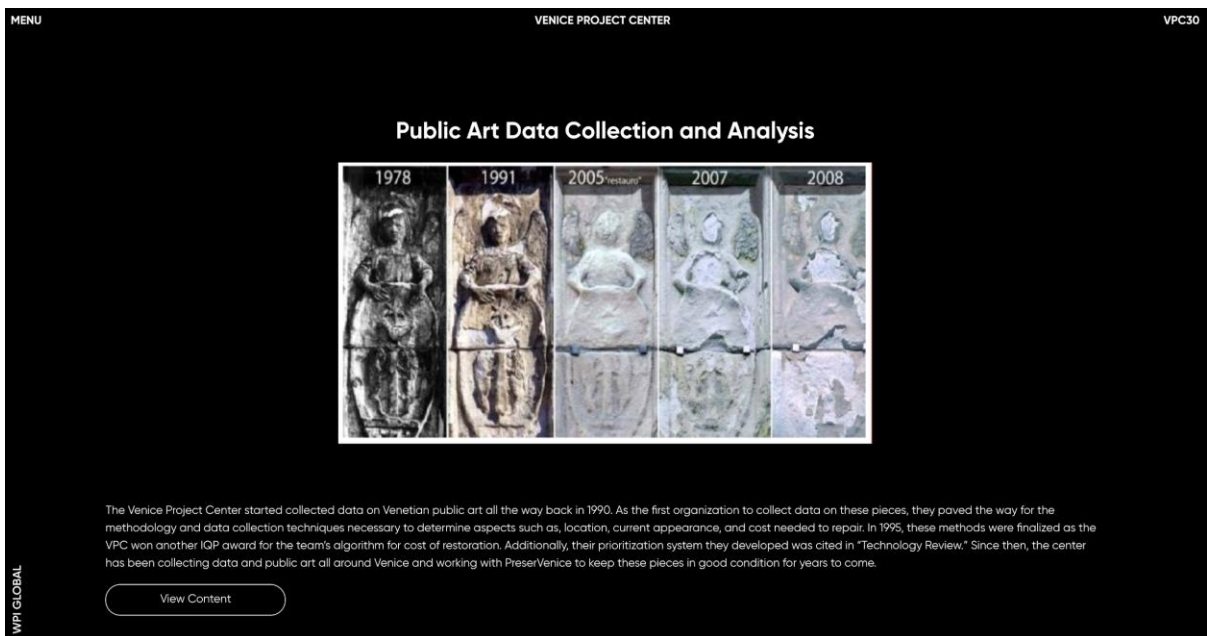
View Content

WPI GLOBAL

Figure 2.2 - Public Art Impact From Website

The Venice Project Center has always pushed for the use of modern technology in its projects. This started in 1989 when an IQP team studied where in Venetian society new technologies could be applied. In the early 1990s, projects used cutting-edge techniques to collect data on the Venetian lagoon, public art, and previously undocumented aspects of the canals. One project of note is Lagoon Archaeology (1990), which was recognized with a WPI Presidential Award, an accolade given to the school's best IQP project of that year. Their project explored how new technology could serve to repurpose the Venetian Lagoon for agricultural development. The very next year, in 1991, a project group created a series of databases to record the inventory of the *Ca' Rezzonico* Museum, winning the VPC's second IQP award. Digital databases were still in their infancy, and this project served as an example for future VPC teams on how to collect and store data for historical artifacts across the city. This work continues today, and it has become a highlight in the endeavors of the Venice Project Center (Figure 2.2).

During the 1990s, the VPC focused efforts on studying the canals. They were the first organization to create an identification system for canals, which enabled later IQP teams to document canal segments, hydrodynamics, and sediment build-up. One team in 1997, combined canal, bridge, and tide data to determine better ambulance routes during high tide, as the elevated water levels make some canals inaccessible (Behmke et al., 1998). In 1997, a team proposed a new Venetian sewage system based on data collected in past projects. This award-winning team verified the locations of sewage holes in canal walls and studied where their waste buildup was harmful. From there, they were able to assess the feasibility of implementing a HIFLO vacuum to coexist with Venice's gravity-based sewer system. In 1998, a team continuing this work won another IQP award for further analysis of the sewage system. They also estimated the amount of sewage discharge into the canal, and provided this information to the city of Venice. The data was then used to improve the conditions of the

canals and relieve Venetians of potential health hazards. As the Venice Project Center arrived at its 10th anniversary, they were able to look back on a productive first decade.

At the turn of the millennium, the VPC was one of the first to research the effects of tourism in Venice by counting pedestrian traffic and determining where it affected the city most. In 2001, the VPC earned an IQP award with a project that re-engineered the cargo delivery system of Venice. Cargo boats contributed significantly to the city's traffic problems and, after analyzing this issue, the team found that the boats were not routed efficiently. The VPC proposed a new system that involved shipping items by location rather than by product. When the proposed plan was tested, it cut back on 90% of cargo boat traffic. This project would go on to be cited by organizations such as National Geographic, Wired, and New Scientist. (Figure 2.3)

Figure 2.3 - New Scientist article about Cargo Delivery Plan

The next year, a project titled "Moto Ondoso Index" assessed how the wakes (moto ondoso) of boat traffic affected the canal walls. They studied the causes of moto ondoso and analyzed its effect with different boats and travel speeds. Additionally, they analyzed the previously proposed cargo delivery system and found that it would reduce moto ondoso by 68%. In 2002, another team won an award by surveying the dunes of outer islands surrounding Venice, and using this data to construct a prototype for an environmental atlas of the lagoon. A main deliverable for this team was the methodology they used to collect this data, which has since been replicated and implemented by other organizations.

Throughout the mid-2000s, projects tended to focus more on the preservation of Venetian history. For example, in 2005, one team aimed to preserve the famous maritime heritage of Venice. They created a database of 33 items throughout the city that had nautical significance and created CAD models of them. This project went on to earn the VPC's eighth IQP award. Two years later, the PreserVenice initiative was launched to document and

analyze all aspects of public art around the city. A crowdfunding website was created, enabling anyone to donate to the restoration of specific pieces of art (Kent et al., 2007). Cultural preservation continues to be one of the main focuses of the Venice Project Center.

In 2009, the VPC pioneered cruise ship documentation in the city. This project studied the hydrodynamics of wakes created by these large ships and the impact of the ship's passengers. This team also created a time-lapse video that captured the flow of tourists moving into the city and conducted surveys to assess their spending habits.

In 2013, the VPC celebrated their 25th anniversary by starting an open data initiative. Applications were developed to display VPC data in real time, and others were created to display comprehensive information about bell towers, bridges, canals, islands, shops, and hydrodynamics. The City Knowledge Dashboard (Figure 2.4) is particularly useful because it displays live information about the city, much of which is tourism related. The user can also view tide levels and available Airbnbs.
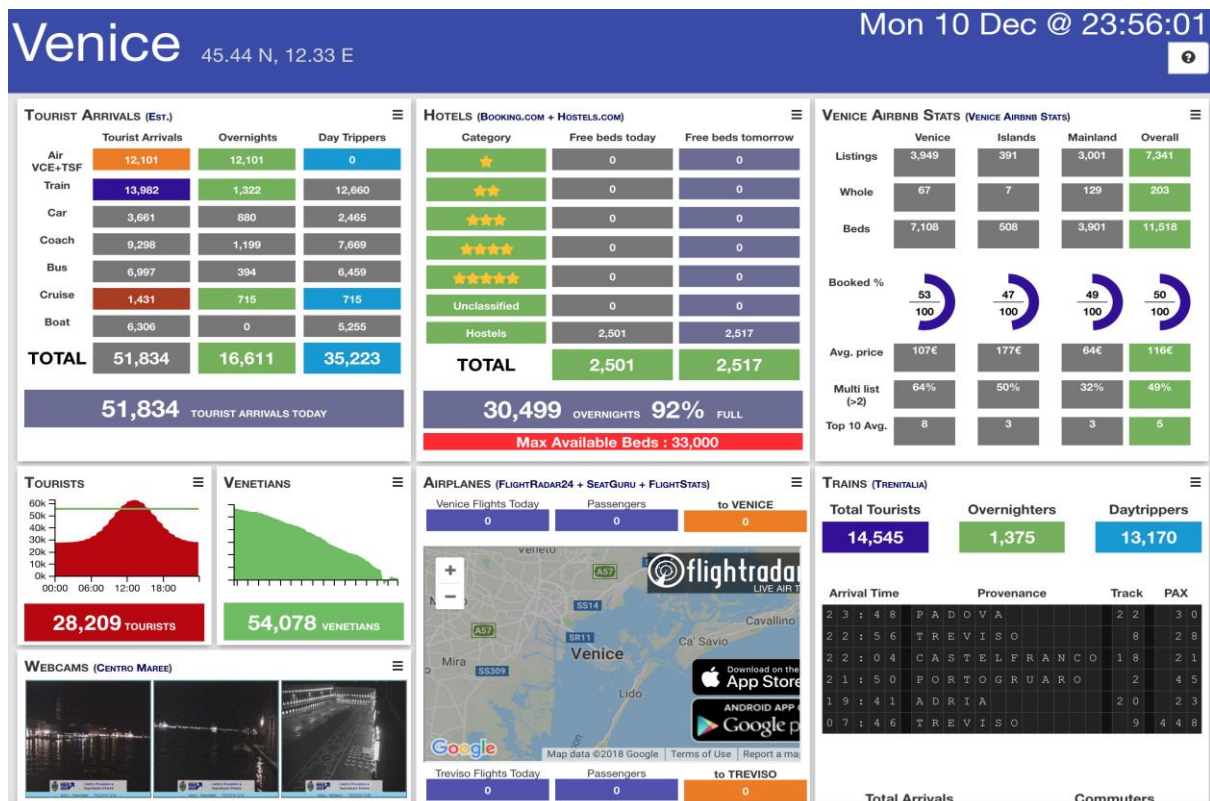

Figure 2.4 - City Knowledge Dashboard

2.2 Present Day at the VPC

The ideals that sparked that Venice Project Center's creation are still apparent today. The VPC has now developed a massive database, called the CK database, with over one million data points. As the 30th anniversary arrives, the project center will be publishing this data in a series of booklets called "Knowing Venice." Each booklet (Figure 2.5) will be focused on a single topic about Venice, with over 30 individual subjects covered. In order to supplement the text, a 2017 team created the Sandbox application to design data visualizations using VPC data. It is capable of creating static visualizations for the booklets, as well as interactive graphs for online use. The booklets will have associated digital infographics that can be found by scanning a QR code on the back of each booklet.

Figure 2.5 - Knowing Venice Booklet Covers

The VPC 3.0 Website (Figure 2.6) is another way the VPC is celebrating its 30th anniversary. This new website is a central location for VPC information, including impacts of the Venice Project Center, applications they have designed, documents they have published, media they have featured in, and student research completed by the center. To go with the anniversary, the Venice Project Center relocated to a new headquarters on the island of Giudecca called "H3" that will serve as a workspace for future IQPs. The H3 complex can also be used to host lectures and VPC functions. This 30th anniversary provides an excellent time to look back on past accomplishments and towards the VPC's future endeavors by striving to "leaving Venice better than we found it."
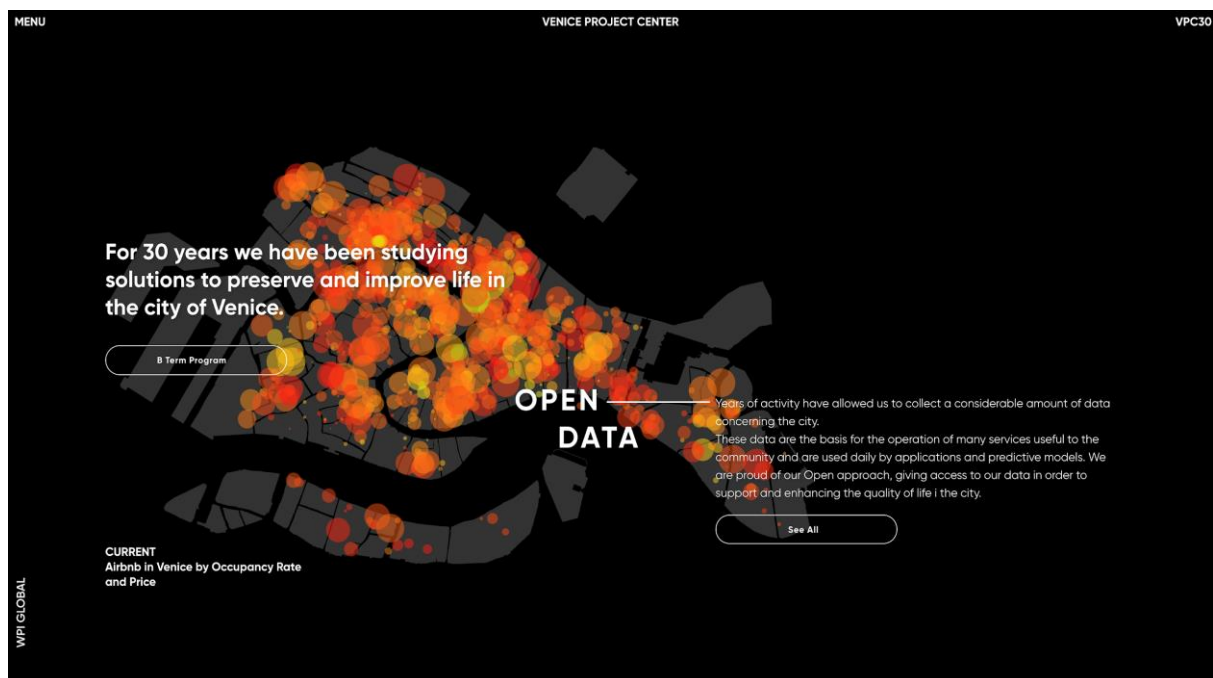

Figure 2.6 - Screenshot from VPC 3.0 Website

3.0 Updating the VPC Online Presence

This section will discuss our initiative to increase the VPC's online presence. We developed a timeline tool to highlight the most important events in the VPC's history. Also, we contributed to the new VPC 3.0 website by allowing users to find information more intuitively. Furthermore, we launched a new social media campaign by creating an Instagram account. We also developed an interactive infographic about the bridges in Venice. Each of these deliverables helps to digitally publicize the VPC's impacts on Venice.

3.1 Creating a VPC Timeline

In order to convey the influential history of the VPC, we decided an interactive timeline application would be an effective medium. It includes a variety of aspects concerning the VPC's history from projects to publications. We made sure that the timeline is responsive, easy to modify, and focused on the most notable achievements.

3.1.1 Creating Content for the Timeline

We started off by gathering content for the timeline application. We sifted through VPC documents and projects in order to identify critical points in the Venice Project Center's history. We also talked with Fabio Carrera to get his assessment of the most significant projects and milestones from the past 30 years. Once we assembled a comprehensive list, we categorized content into four subjects: IQP Awards, Applications, Publications, and Milestones. From there, we gave each timeline event a title, date, and short description. We added impactful images, videos, and links to supplement each event. The links allow users to navigate to different areas of the VPC website and read more about the topic. The links attached to publications will take users to a PDF of the document. In Figure 3.1, the user can see the Read More link attached to the Smithsonian article (outlined in red), and clicking it will reveal the original article (right) where the VPC was mentioned or quoted.
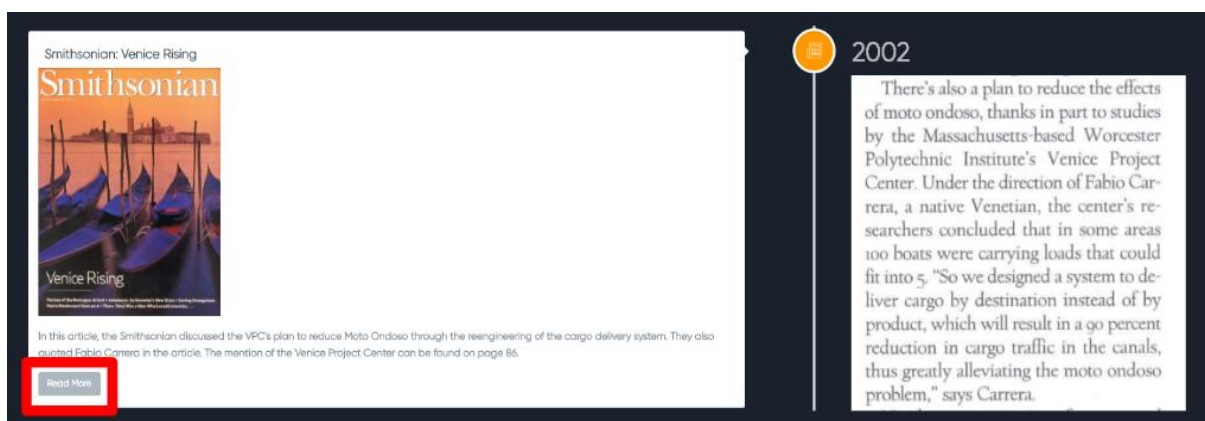
Figure 3.1 - Smithsonian Publication

3.1.2 Building the Timeline Application

Once we organized all of the timeline material into a spreadsheet, the development of the application began. The spreadsheet we created provides an easy way of adding, deleting, and modifying the timeline data. Subsequently, we added scrolling animations so events animate when they move on and off screen, and we aimed to match the visual design of the timeline with the VPC 3.0 website's appearance. We also added functionality for timeline blocks to display images or videos. Lastly, we added the ability to filter and sort events chronologically or by category, as seen in Figure 3.2.
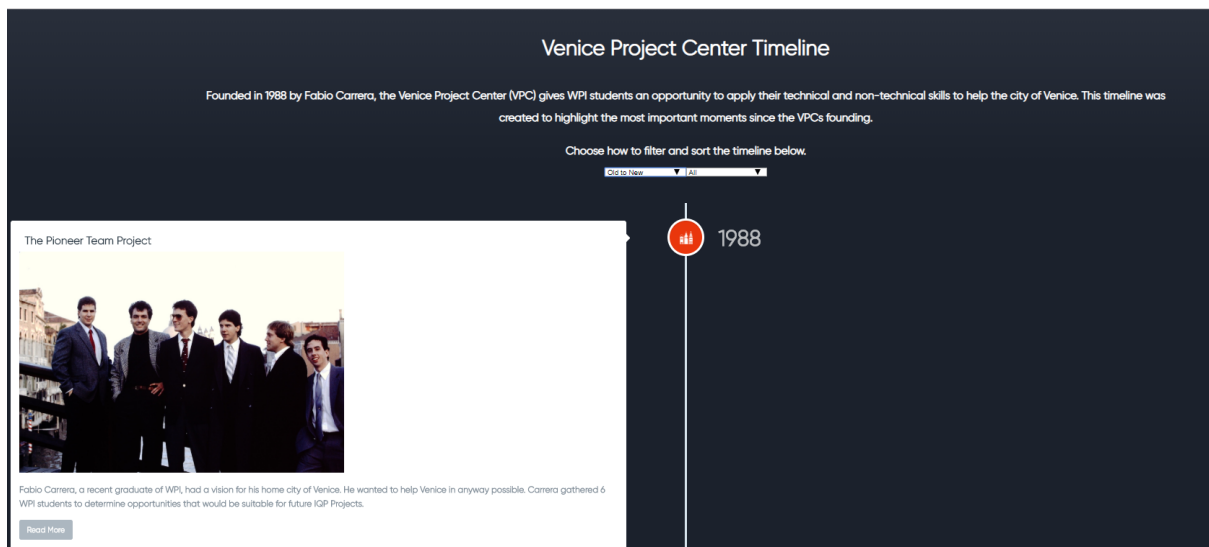
Figure 3.2 - Timeline Header and Pioneer Team Content

3.1.3 Recommendations

The timeline application will serve as a method to highlight the most important VPC achievements. We recommend that future teams further refine the timeline by adding a search function. We also recommend that they add a slider to allow users to quickly get to a desired year or time period. Both changes will make the timeline more user-friendly. In addition, we recommend that future teams populate the timeline with more milestones as the Venice Project Center reaches new heights.

3.2 Updating the VPC 3.0 Website

In 2018, the VPC officially released the 3.0 version of it's website. Our team made improvements to the website and created website content in order to ensure that the new site was representative of the work completed by the VPC.

3.2.1 Implementing Clerical Fixes

Because the VPC 3.0 website is still in development, we discovered that there were spelling and grammatical errors. We proofread the pages of the website to fix the typos we found. Additionally, we made it easier for prospective VPC students to learn about the VPC, the work they could be a part of, and their hypothetical experience in Venice. This was done by changing the wording on IQP page to be as clear as possible. Future students will be able to find the information they are looking for about the VPC quicker.

3.2.2 Updating IQP Categories and Abstracts

In order to organize the list of IQP reports on the "Projects" page, we categorized all of the Venice Project Center's IQP and MQP projects. Each project was assigned "Venipedia Portal", "Main Category," and "Topic" tags, in order of increasing specificity. We put this categorization data on the VPC 3.0 website so users can find projects by any of their tags (Figure 3.3). Additionally, we updated the website's catalog of abstracts for each project to ensure that they were correct and present.
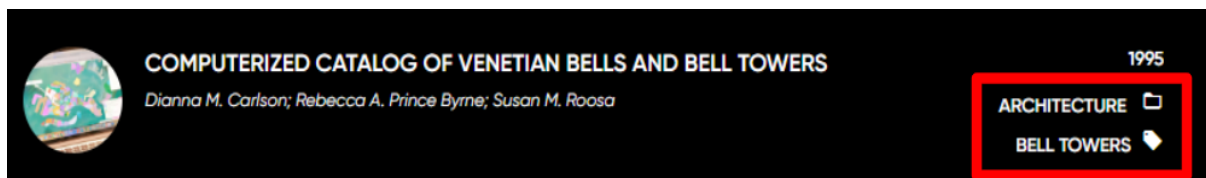
Figure 3.3 - Project Categorization Example

3.2.3 Making Changes to the Menu System
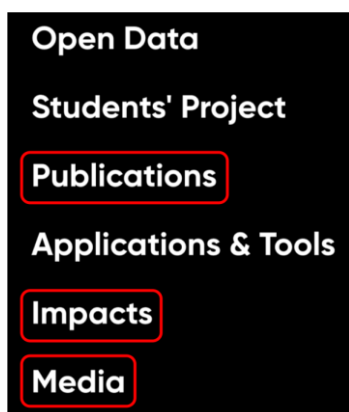
Figure 3.4 - VPC Website Menu

Originally, contents on the VPC 3.0 website were disorganized, making it difficult for the user to navigate intuitively. The "Impacts" page contained works created by the project center. The "Publications" page contained articles that the VPC was interviewed or cited in. Because of this disparity, we decided to reorganize the pages. We started by creating a new "Media" page, where we moved the VPC's interviews and citations. Then, we moved the center's published works from the "Impacts" page to the "Publications" page. To fill the newly emptied "Impacts" page, we interviewed Dr. Carrera to learn more about the VPC's major impacts. From this interview, we wrote short descriptions (found in Appendix D), added pictures, and attached relevant links so the user can access additional information about each impact. The separation into "Media", "Publications", and "Impacts"

pages makes finding information on the website much easier. This new menu system can be found in Figure 3.4.

3.2.4 Recommendations

The new VPC 3.0 website is an excellent starting point for the VPC's updated online presence. It is important that it is continuously maintained to provide the most up to date information on the center. We consider it crucial that the website continues to cater to both WPI students and other people interested in learning about the Venice Project Center.

3.3 VPC Social Media

Social Media continues to be a driving force in today's society. It provides a way for organizations, including the VPC, to spread the word about their achievements. We made posts on the VPC Facebook page and created an Instagram for the project center. We used both platforms to publicize the work done over the past thirty years and to educate people about how the VPC has influenced Venice.

3.3.1 Creating and Posting Content to the VPC Social Media

We created the Venice Project Center Instagram so people can stay updated on the latest project center news. We launched a "VPC Impact Week" the week leading up to final IQP presentations to celebrate the 30th anniversary. Each day of the week, we posted about a different impact that the center has had on Venice (Figure 3.5). The five impacts we posted about were Canals, Public Art, Cargo Delivery System, Boat Traffic, and Moto Ondoso. We made similar posts on the Facebook page with links to the Instagram to connect both platforms. In order to increase awareness of these pages, we also reached out to the VPC alumni via email to notify them of the new social media accounts.
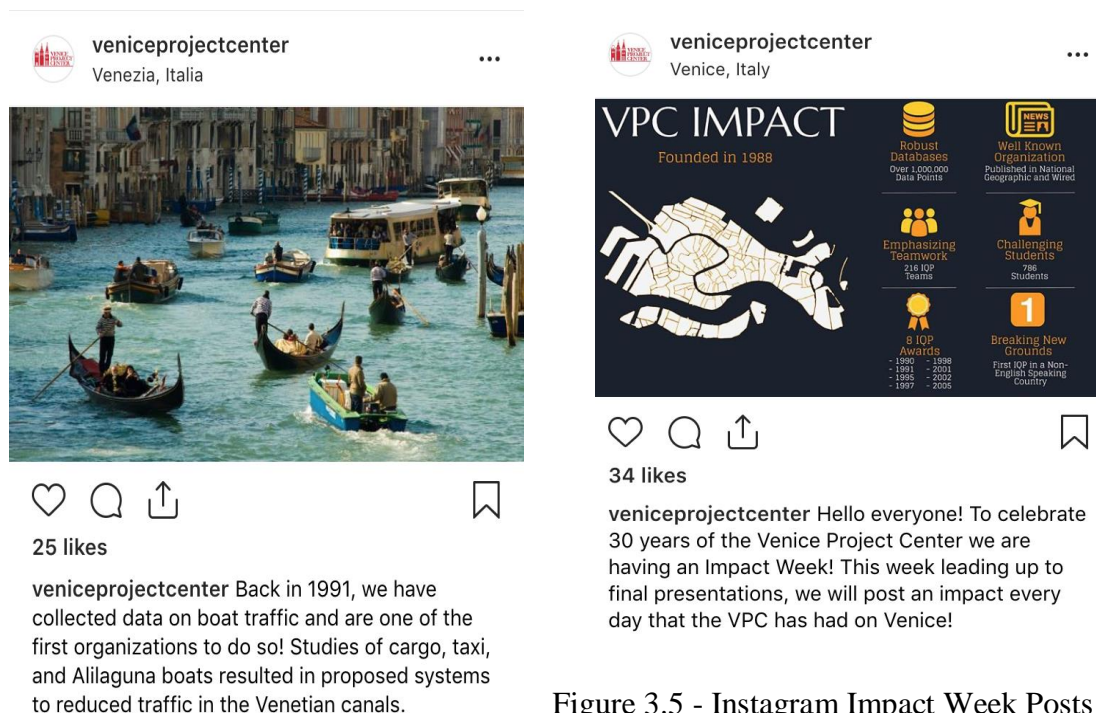

Figure 3.5 - Instagram Impact Week Posts

3.3.2 Recommendations

We believe that the VPC Instagram is an excellent opportunity to increase project center's social media presence. We recommend that the page is regularly updated and that content is created for "Instagram Stories." The main VPC Instagram can also be linked to the Instagram accounts of individual student projects, which can serve as a way to keep the page relevant through subsequent years. Future teams should take advantage of the Instagram account to publicize any student events held at H3. Connecting VPC social media accounts with other WPI accounts would help the VPC expand its network of influence.

3.4 Creating an Interactive Bridge Infographic

The bridge data is the most complete data set in the VPC database. For this reason, we created an interactive infographic about the bridges of Venice. Once the "Bridges" booklet from the "Knowing Venice" series is published, the infographic will be accessible by a QR code on the back of the booklet.

3.4.1 Collecting Updated Bridge Data

To ensure the VPC's bridge information was as complete as possible, we identified eight bridges with data that needed to be surveyed. We collected data on these bridges to gather their height, number of steps, handicapped accessibility, and other statistics. We used a tape measure to measure different parts of the bridge. For the height, we used a plumb-bob to measure the distance between the bridge and the surface of the water. Then, we recorded the time of measurement so we could find how high the tide was at that time. From there, we could calculate the height of the bridge at average tide by adjusting the height for the change in tide. Once we finished our field visits, we calculated more complex measurements such as surface area, hypotenuse, and inclination, and added both recorded and computed fields to the CK database. When surveying, we noticed there were bridges connected to a new island constructed on Giudecca. We added this island, along with its canals and canal segments, and all of the bridges we collected data on, to the VPC GIS layer that is displayed below in Figure 3.6.
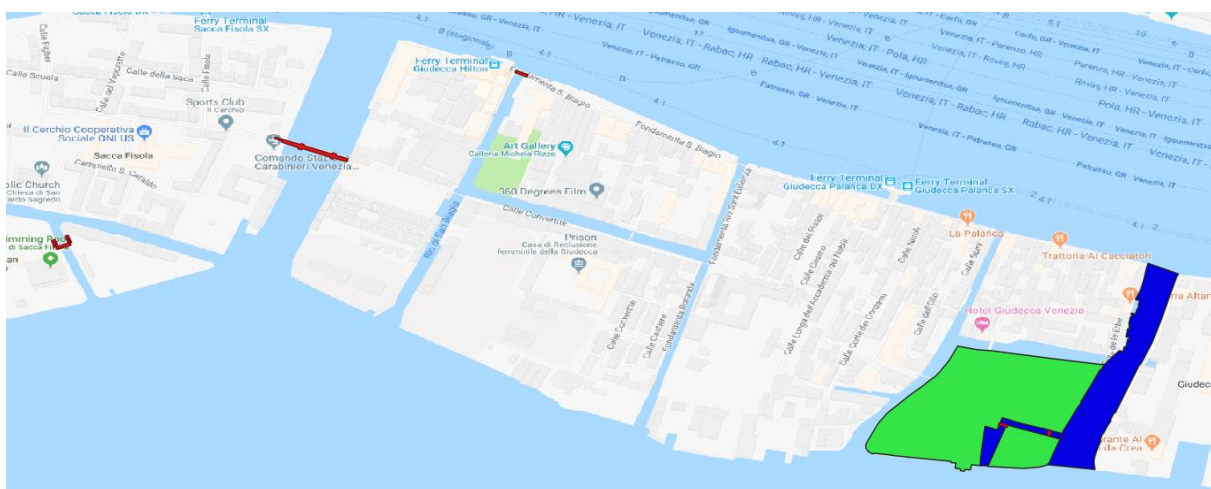

Figure 3.6 - New Giudecca GIS Layer

3.4.2 Using the Updated Bridge Data to Create an Interactive Infographic

Using the newly updated bridge data, we created an interactive infographic that depicts the cumulative height of all the bridges in Venice (Figure 3.7). We chose to make this infographic a bar chart so that the graphic would look like stairs. The infographic allows users to zoom in to a portion of the graph, and users can hover over a bar to see more details about the corresponding bridge. Clicking on the bar shows the Google Street View of the bridge. Additionally, bars that represented handicapped accessible bridges are colored green, while the rest are colored red. We kept the new style of the VPC 3.0 website in mind to make the pages as cohesive as possible.
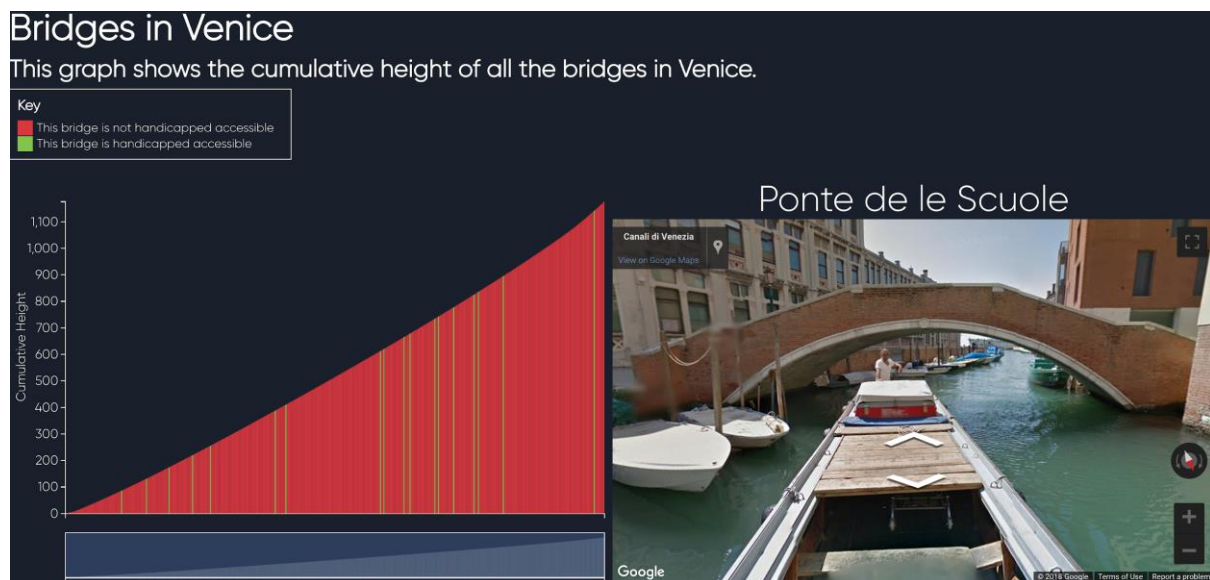
Figure 3.7 - Screenshot of Bridge Infographic

3.4.3 Recommendations

We advise that future teams create other interactive infographics about bridges and other studied topics. These graphics should incorporate a multitude of variables and interactive features to show as much information as possible. A search bar would be very useful to add to this infographic, as there is no way to quickly find a particular bridge in its current state. This is an example of an infographic to be attached with the bridge booklet. As more booklets come out, we would encourage teams to create infographics based on the corresponding topics of the booklets.

4.0 Sandbox: A Data Visualization Tool for Print Booklets

A data visualization is a coherent representation of numerical information, usually in a graph, that allows people to visualize and identify trends associated with the data (Lee, 2017). The following section will cover the Sandbox application, which was a focus for our team because of its versatility in creating graphs from VPC data. It was created in 2017 by the "Knopen" Team (Bishop et al., 2017), and allows users to interact with VPC data through the creation of interactive graphs. Sandbox examines VPC data stored in the CK database; the flow from collection to visualization can be seen in Figure 4.1. When creating a graph, users are able to select a data set and graph type, and the application automatically generates a graph of the data. From there, the user is able to customize the graph by adding elements such as titles, descriptions, labels, and color palettes. The VPC plans to use the tool in order to create static infographics for the "Knowing Venice" booklets, and digital infographics for publication on the VPC 3.0 website.
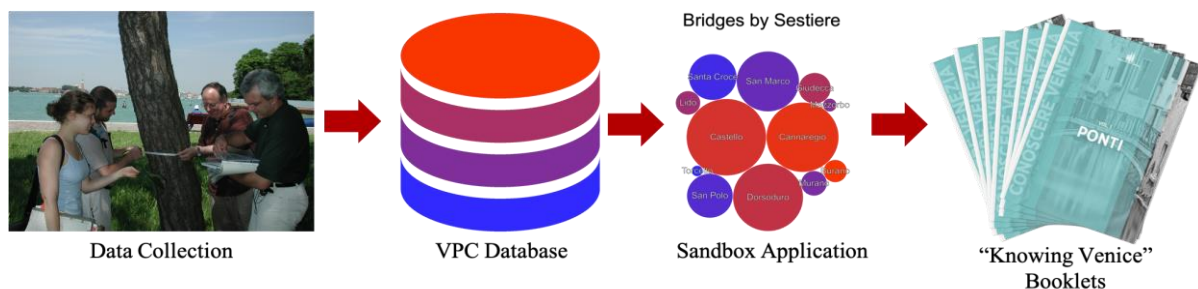

Figure 4.1 - CK Database Infographic

4.1 Updating Sandbox to Create Better Visualizations

The "Knopen" team of 2017 created a framework for Sandbox that allowed us to further enhance the application. We improved the visual aspect of both the menu and the graphs, especially in color scheme and layout. We were guided by the goal of making the Sandbox application simple to use, but still capable of creating highly tailored graphics.

4.1.1 Improving the User Interface and Visuals of Sandbox

The first aspect that we improved were the menus and organization of the application. Previously, the user had to visit three separate web pages before actually creating the graph, as shown in Figure 4.2. If a user decided to change either the graph type or data set, they had to navigate back and forth through these pages. Now, we display all of these options on a single page, which allows users to quickly switch between them and reduces the time needed to create visually appealing graphs. It also allows the user to experiment quickly with different graph types without wasting time having to re-select their options. Furthermore, we divided other graph settings into a dropdown menu, which prevents the menu from becoming too cumbersome and helps to organize the settings in a more logical manner. Figure 4.3 highlights the new menu structure of Sandbox, with the content of the two removed pages being highlighted in red. We also redesigned the header and footer to emulate the look of the

VPC 3.0 website. We minimized the header to avoid cluttering the page and to give more room for graphs. Credit was given to WPI and the VPC in the footer.
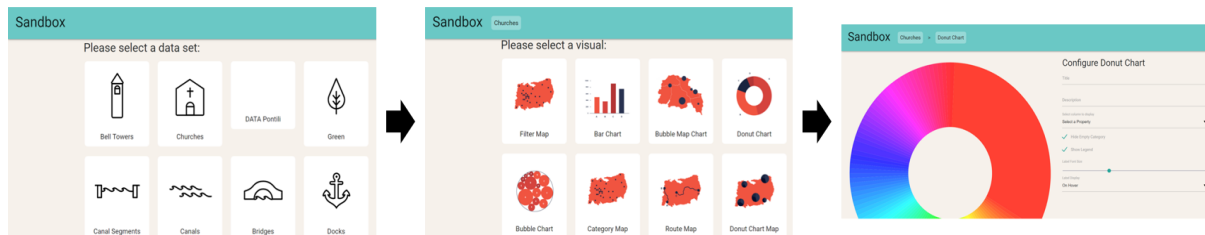
Figure 4.2 - Old Sandbox Menu Screen
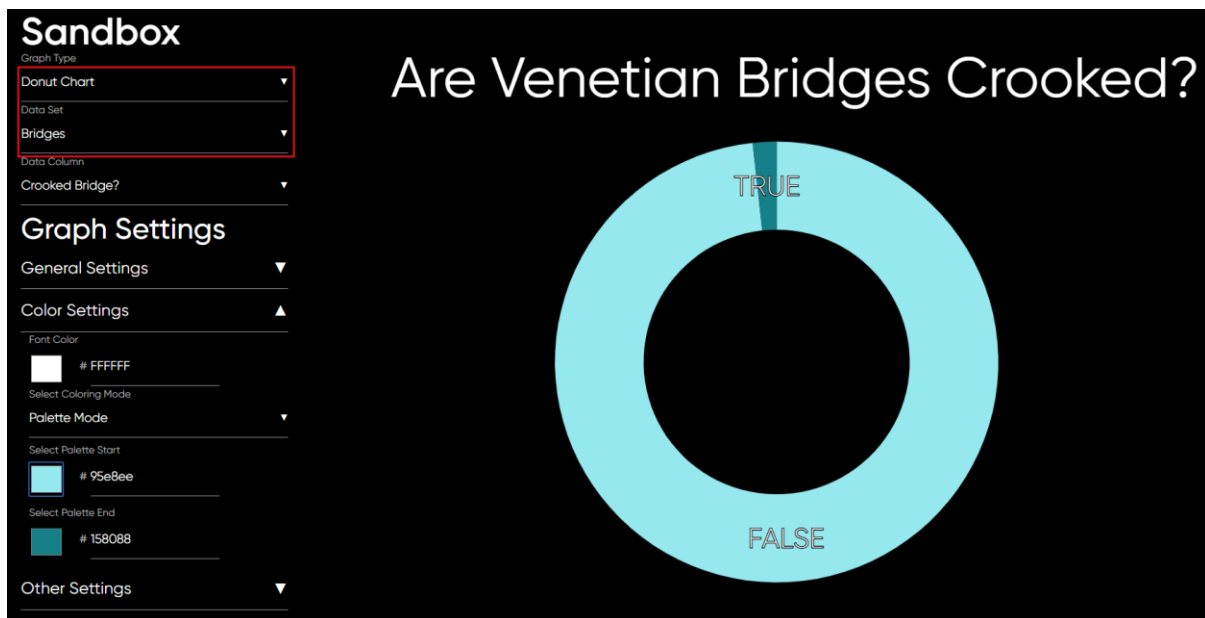
Figure 4.3 - New Sandbox Menu Screen

Figure 4.4 - Sandbox Legend

We also worked to improve the visual appearance of Sandbox. We changed the font to match the new VPC 3.0 Website and used its black and white color scheme to maximize the cohesion between the two websites. We also needed to rework the graphs to fit on the page. They were larger than the size of the screen before our updates and could not be resized, requiring the user to scroll to see the entire graphic. Now, the graphs automatically resize so they fit on the page, with as much space as possible given to the graph, even with the presence of a title and key. The key was heavily reworked to ensure it also fit on the page, with other improvements made to spacing, text wrapping, and visual design. The key, shown in Figure 4.4, now gets its own space on screen with a scroll bar if needed. Additionally, the user is allowed to change where the key appears relative to the graph. The key automatically positions text inside of it, and has a white border to encapsulate it. Several small changes were also made to individual graph types to make them more flexible. Bar graphs, for example, now have customizable labels for the x and y axes.

Figure 4.5 - Sandbox Color Picker

To pair with the new design of the menus, we added new options for colors. Previously, the color options were highly limited. Graphs were rainbow by default and could only be changed by selecting pieces individually and altering colors. There was also no option to change font color. In order to give the 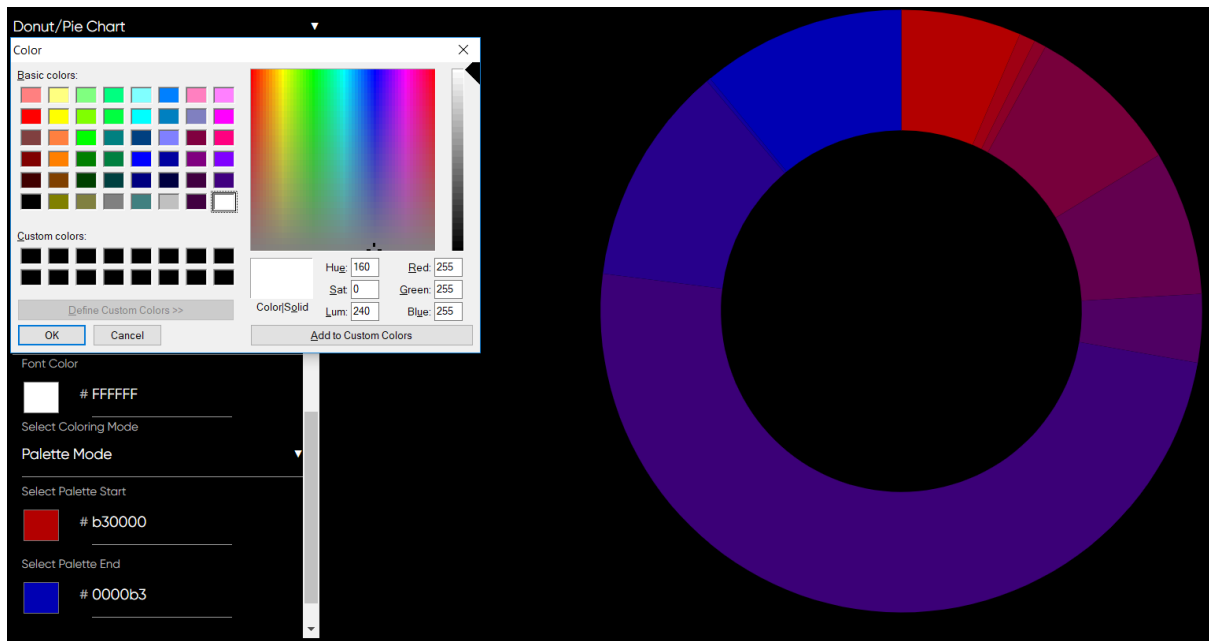user more flexibility, we added a palette mode that allows the user to produce a gradient between two colors quickly by selecting a start and end color. All of the graph pieces will be automatically filled in to match the selected color scheme, and the color palette will persist even if other options are changed. This is especially helpful for making graphs meet an existing color style. However, we maintained the ability to recolor pieces using a manual selection mode, which allows users to pick a color for each piece of the graph. Users are also given the option to set a font color, which affects the key, title, and labels. Color options can be seen in Figure 4.5 above.

4.1.2 Making the Sandbox Code More Robust

Our team also improved the backend data organization. Many graph types used different methods for storing and using data, which made it difficult to move features from one graph to the other. To correct this, we created a standardized method for storing data and attributes that allows us to reuse features for all graph types and streamline future development of the application. Our new data organization system also opened avenues to more effectively sort the graph data, so we added an option to choose between sorting methods.

The VPC is now using the CK database to store all of its data, so Sandbox had to be updated to take the most recent data from the new database. This ensures that graphics are created with the most up to date information. We left functionality to use Sandbox's old database, Firebase, in case the Venice Project Center decides to switch back. Furthermore, we made it easy to add other database functionality if the VPC changes databases again.

4.1.3 Increasing Customizability for Graph Creation

Following our backend updates to Sandbox, we added a way for users to save and upload their own graphs. After graph tailoring, many users would want to save their graph. We added the ability for users to save their graphing progress using a custom file type, a ".sndbx" file. They can then upload that file to the website later in order to resume work on that graph. In addition, users can export their graph to an image file (.png) so they can use it in other projects. Both of these save the user time and effort that would be spent exporting and re-creating graphs.

Lastly, we wanted to make Sandbox as accessible as possible for new users. We created a guide (Appendix E) that new users can read in order to learn how to use Sandbox. This will help new users become acclimated to the application, and will enable them to create the best graphics possible. Also, we added an option for users to filter out empty data. The filter also removes columns with more than fifty different data points inside, which would create very cluttered graphs. This can be disabled from the options menu, but is left on by default to keep from overwhelming new users.

4.2 Using Sandbox to Create Imagery for the "Knowing Venice" Booklets

The Knowing Venice are currently lacking defined and informative imagery to support the text. To aid in their publication, our team provided this visual information in the form of graphics. Figure 4.6 is one example that shows a mockup of a page from the bridges booklet and features a graph we made in Sandbox.

After the rework of Sandbox, we were able to create graphics that can be incorporated into the corresponding
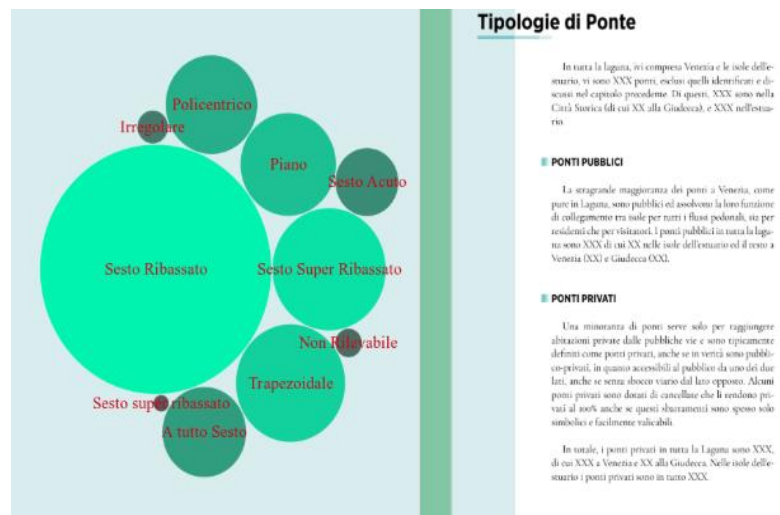
Figure 4.6 - Bridge Booklet Example Graph

booklets. We decided to focus on the Bridges booklet as it had the most complete dataset. Figures 4.7 and 4.8, shown below, are a few graphs we produced using Sandbox. Because the graphics are exported as a file with no background, any Sandbox produced graphics can be combined into larger infographics with text, or simply added as a standalone. Furthermore, as more data sets become complete, the Sandbox tool will need very minimal changes to accommodate the new data.

Bridges with an Additional Handrail
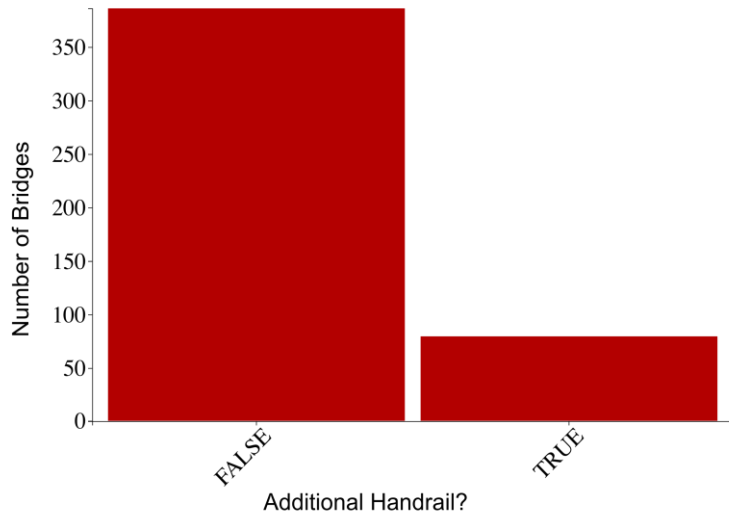
Figure 4.7 - Bar Graph Created with Sandbox

Where are Venice's Bridges Located?

Figure 4.8 - Bubble Graph Created with Sandbox

4.3 Future Recommendations for Sandbox

One of the major improvements we made to Sandbox was reworking old code. Any future teams that work on sandbox should use the multitude of functions in the Visual class, which serves as a baseline for each graph type. This Visual class handles events such as data collection, key rendering, and graph resizing, and can be accessed to provide this functionality to any new graphic types. Additionally, we standardized data storage in a graph attribute called "items" that is used for the active graph's data storage, which further helped in making code reusable. Instead of needing to get data from the database with each graph option change, we instead use "items." "Items" can then be referenced in a multitude of other functions without the need to specially tailor them. It is imperative that future updates maintain uniformity among graphs to avoid the need to rewrite old code.

Because of the immense amount of refactoring, we were forced to remove some of the graph types that were once available in Sandbox. Because the graphs had limited functionally and were very inconsistent in implementation, we decided that removing them and adding them back later would be more time effective and produce a better product. Because of our standardization, future teams should now be able to more easily add graph types. Treemaps, tables, and map graphics such as a heatmaps would be very interesting additions to Sandbox's repertoire.

One feature that could be added is the ability to dynamically select datasets from the CK database. Because there is no feature in the API for getting the names of all data sets, there is no way to sift through them for usefulness. Even if there was, the datasets vary drastically in completeness and nomenclature. We could not determine a way to identify datasets that were in an appropriate state for visualization, which would be exceedingly useful to make Sandbox relevant for a longer time period. This would likely involve creating a standard for column names that would be shared among relevant data sets, as well measuring the completeness of all of the VPC's data sets.

Uploading custom data sets would be another feature that would make Sandbox more useful. They could use the graph creation feature without being boxed into the VPC data that we deem appropriate. This could also be helpful for other IQP teams who are interested in creating visualizations before uploading the data to the CK database.

Lastly, increasing user freedom to move graph elements would be an improvement. For example, donut charts have a feature to change the order of pieces, which is not possible for bar charts. The data is the same, but users do not yet have the ability reorder it. Adding the ability to move pieces of a bubble chart would also give the use more flexibility.

5.0 Helping the VPC Acclimate to their new Headquarters in H3

The Venice Project Center's headquarters moved from their old location in central Venice, to H3 on Giudecca. Our team was responsible for moving the IQP report archive from the old building to H3. We organized all of the projects in chronological order so that they could easily be found in the archive. Many of the IQP reports' boxes were old and battered, so the VPC planned on getting new boxes for all of them. This process involved creating new box labels for each project that include projects' name, year, team members, and sponsor. We were responsible for creating the new labels, two examples of which can be seen below in Figure 5.1. More information about these labels and how to update them can be found in Appendix C.
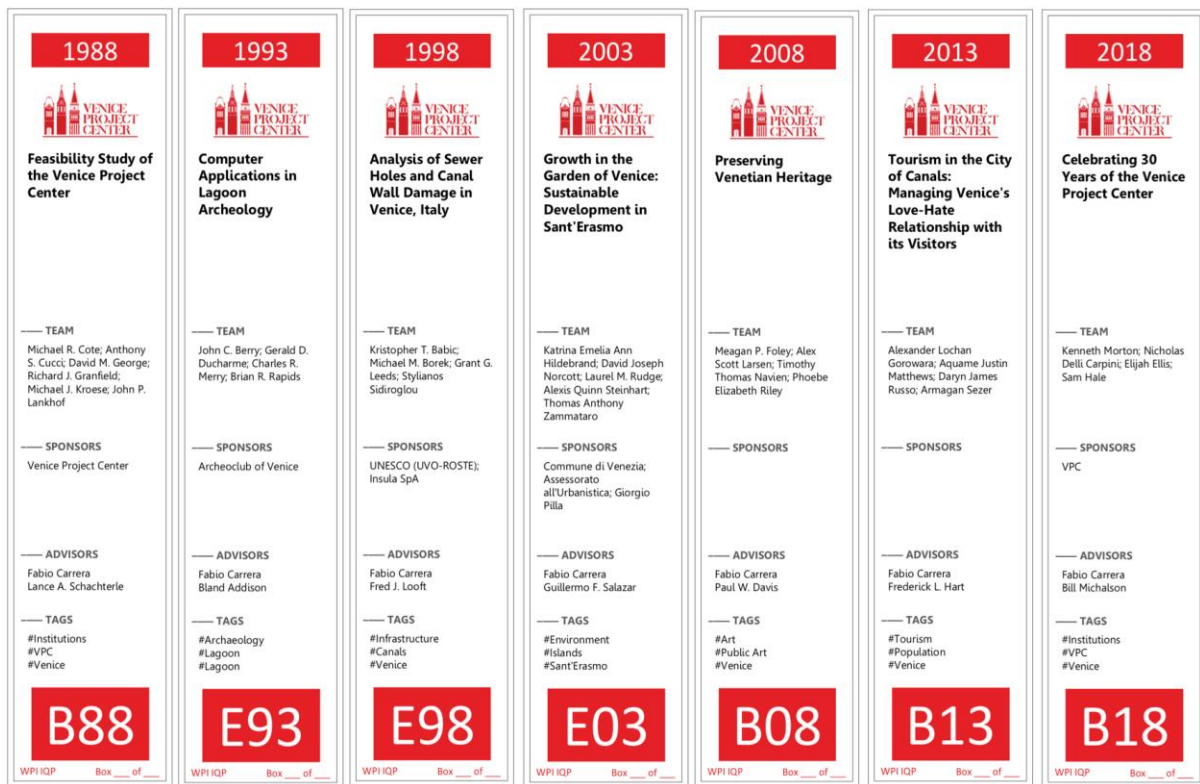
Figure 5.1 - IQP and MQP Labels

6.0 Conclusion

We are glad to have helped the Venice Project Center celebrate its 30th anniversary. In order to complete our goal, we updated the online presence of the VPC to showcase the work they have done with both our timeline application and the restructuring of the VPC 3.0 Website. We also developed ways for the VPC to move towards their future endeavors by bolstering their social media presence and refining the Sandbox tool. This tool will allow the VPC to create graphics that will be used in both the VPC 3.0 website and the "Knowing Venice" publications. We encourage future teams to continue to research and understand the project center's influence over the last 30 years. Additionally, we urge teams to advance the applications we have developed, as they can be powerful assets for the VPC. We hope that future teams continue to help the Venice Project Center make strides towards its mission of "leaving Venice better than we found it."

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Appendices

Appendix A: Data Visualization

It is important to ensure that visualizations support the text and help the readers take away important information. An infographic grabs a reader's attention by combining information in a clear and concise way; it is a method to display lots of information in a condensed format (Siricharoen 170). When using infographics, it is important to remember that the goal is to catch the reader's attention and simply display the meaning that the text is trying to convey. Infographics can be broken down into four types: statistical, timeline, process, and geographical (Siricharoen 171). The best type of infographic to use is dependent on the data. Bar charts, diagrams and tables are statistical and are usually the most popular due to their simplicity. Figure A.1 is a good example of a printed statistical infographic which is eye catching but still clear in its point (Siricharoen 171). As seen in Figure A.3, timeline infographics are used to show trends over a duration. Process infographics are similar but, as shown in Figure A.2 are used to explain a complicated procedure in a limited amount of space. Lastly, geographical infographics are used to help identify different objects on a map as shown in Figure A.4. These objects can include streets, canals, bridges, facilities, or other types of icons around a city (Siricharoen 171).
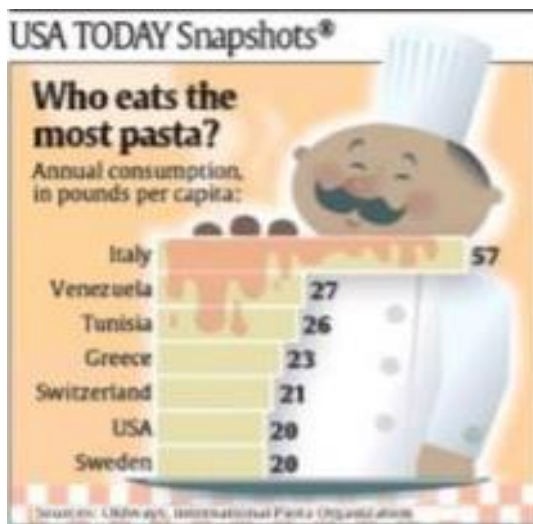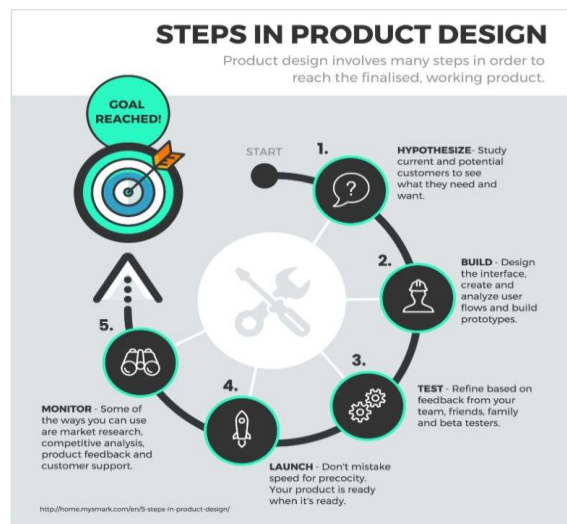

Figure A.1 - Bar Graph Example
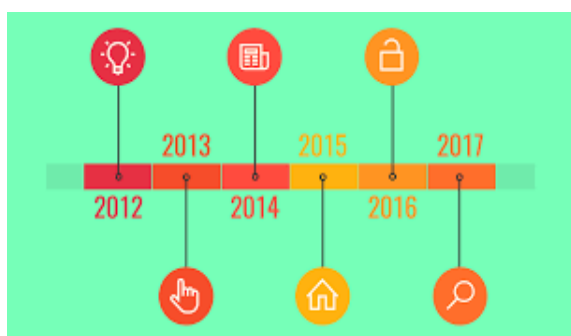

Figure A.2 - Procedural Graph Example

Figure A.3 - Timeline Graph Example

Figure A.4 - Geographical Graph Example

Along with displaying information, it is important that infographics are impactful and engaging. Data visualization experts identified 5 major components of infographics to achieve this: immediacy, malleability, engagingness, resonance, and coherence (Dunlap and Lowenthal, 2016). Immediacy is important in order to "create a sense of urgency" for the situation that is presented (Dunlap and Lowenthal, 2016) which can be established through making the infographic appealing through the color scheme and title. Malleability and engagingness define having the reader find a point of relevance to the infographic through its structure, which requires that the infographic has a clear story to tell. Resonance defines having the learner get a lasting effect from the infographic (Dunlap 2016). Lastly, none of that is possible without a coherent infographic that is able to share a complete and consistent message. After an experiment conducted by Dunlap and Lowenthal, coherence was the only trait they found that was overwhelmingly identified in all of the most impactful infographics, such as in Figure A.5 (Dunlap and Lowenthal, 2016). This particular graphic displays lots of information and statistics, but maintains an overall message throughout the entire infographic. In addition, the color scheme and spacing are consistent among visualizations. Keeping infographics coherent will help incorporate all of the other necessary traits to create ideal infographics.
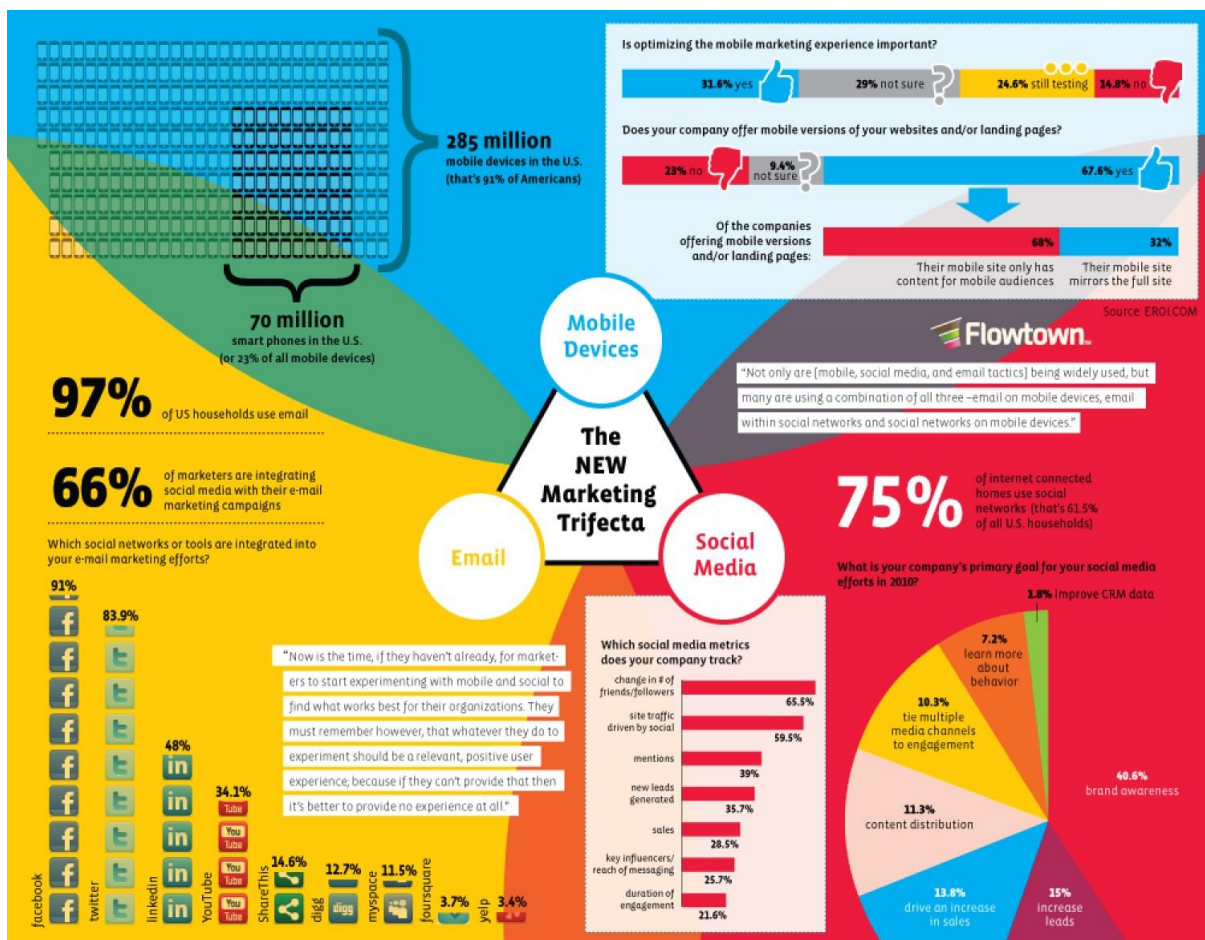

Figure A.5 - Impactful Infographic Example

Appendix B: Sandbox Technical Write-up

B.1 Brief Explanation of Sandbox Structure

The program begins execution at routing.js, which does a few basic setup functions and then sends the user to a webpage based on the URL. This will most likely remain unchanged as Sandbox has one primary webpage. The bulk of Sandbox will be managed through the editor.js and Visual.js files, which contain the code for data structuring and the js code that adds to the html. The actual html file contains very little formatting except for templates that get used in EditorGenerator.js to create menu items. The graphs are rendered using a visualization library called d3.js.

A large amount of effort was spent refactoring code from individual graphics to the Visual superclass. Because the different graphs had different ways to represent data, it was exceedingly difficult to standardize, especially because of the stacked bar graphs requiring two levels of data filtration. The standard we decided on was a JavaScript object stored in the Visual object's attributes, called 'items.' Between that and other code refactoring, we highly suggest using the functions in Visual for adding additional graph types. Furthermore, the past team's code for graph types that we removed has been left in the repository, so their visualization code can be reused in combination with the abstracted functions in Visual.

Many files remain unused because of the removal of many graph types. The others were left in their original state and would require a hefty overhaul to meet the new data structuring standards and abstracted functions. However, it is likely that the d3.js code will be usable. The Map graphics may also need a sizable overhaul because of the Google Maps API change that happened in 2018.

B.2 Technical Recommendations

We were unable to make Sandbox pull dynamically select data sets for several reasons. Primarily, the CK database's API does not have a way to pull all of the data sets or data set names, so we had to at least input those manually. Furthermore, the structure of tables is drastically different among different groups of data. We could not determine a way to algorithmically determine appropriate data sets, which would be a very useful feature in the future. One potential way would be to create a specific nomenclature for "published" data sets, or add some other marker.

Uploading custom data sets would be another feature that would make Sandbox more useful. An easy format to use would be .CSV files, as a header row could determine keys and is a common enough format that people would recognize it. We started to add it as an option in the Select Data Set dropdown, but were faced with issues related to data fetching. This could be accomplished by adding the csv data directly to Visual's data attribute, and stopping calls to fetch data from the database. We left in the file for parsing .csv files for future teams' use.

Lastly, increasing user freedom in placing thing around the graph would be a nice feature to add. The current method for sorting the data uses the Visual's 'items' attribute (as previously mentioned) and giving each data a weight (with 0 being first and higher integers coming later). The data can later be sorted using these weights, and reordering things would be as simple as changing the weights. Moving pieces of a bubble chart would require much more complicated use of d3.js.

Appendix C: Generating Labels from an Excel Sheet

We wanted to ensure that future labels for VPC IQP and MQP reports are as easy to generate as possible. We did this using a mail merge in Microsoft Word. You can supply an excel sheet to the Microsoft Word label, and word will automatically create labels for each row in the Excel sheet. This appendix will serve as a guide to creating labels in the future. Additionally, you can find links to the documents referenced here or in Appendix F.

1. Download the google sheet called "VPC: Master Project List" as an excel file. Make sure to rename it as "Spine Data" so the word document can recognize it
2. Open the excel file and navigate to the sheet titled "IQP Labels." These are the fields that will be read by the mail merge
3. From here, we would recommend deleting any data you don't want to be included in the new labels. The mail merge process can be taxing on the computer and take a long time.
4. Fill in the new data that you want included in the mail merge
5. Download the Microsoft Word file called "IQP Label Template". Put it in the same folder as the excel document. From here, open up the word document and select the excel document as the data source. Then, select the "IQP Labels" sheet
6. Navigate to the "Mailings" tab at the top (shown in Figure C.1)
7. Select the button "Preview Results" to make sure the labels look like you want them
8. From here, specify a "Merge Range" of which labels you want
9. Click "Finish and Merge", and then "Edit Individual Documents." This will begin the merge, and a new word document should open with all of the labels.
10. Now we will put 3 labels on 1 page. In the new word document with all of the labels, open the "Find and Replace" Menu, (Figure C.2). This can be done by pressing (Ctrl + h) on Windows, or (cmd + shift + h) on Mac. Then, type "^b" in the find field. Put three spaces, "   " in the replace field. Click "Replace All." Once processing is finished, there will be 3 labels on each page.
11. From here, we would recommend that you convert the word document into a PDF for printing.
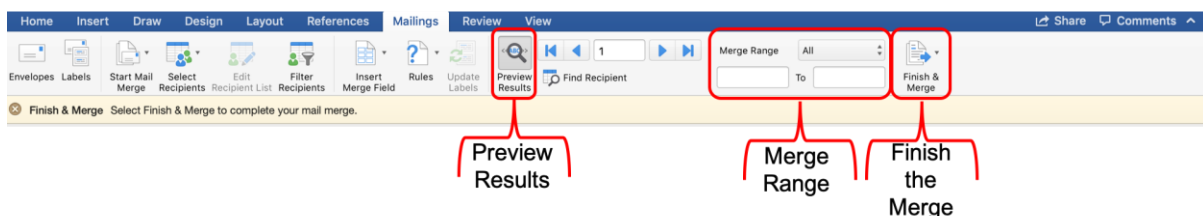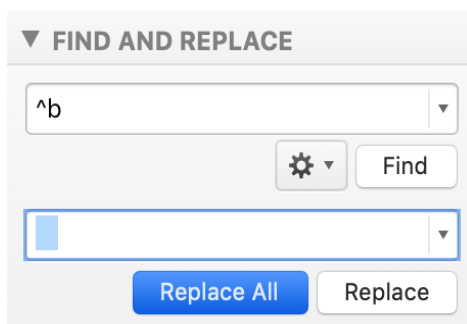

Figure C.1 - Microsoft Word Mailings Tab

Figure C.2 - Find and Replace Tool

Appendix D: Material Written for Impact Page

`   This is the text we created for the website that would go up on the Impact Page. Each section is an impact we featured and what we wrote about it.

Cargo Delivery System:

Traffic is a problem with any highly populated city. However, a different problem with traffic in Venice is the waves boats create (Moto Ondoso) damage the canal structure over time. The Venice Project Center has found a way to reduce traffic through the Cargo Delivery system. Starting in 1997, a project sectioned the city off into delivery zones based on area and business types. Then in 2001, a team used these delivery zones and switched the "by product" shipping to "by destination." Along with this new system, the city would need plans for a warehouse to organize the boats with what objects they need to carry out when. This proposed plan was expected to reduce cargo boat traffic by nearly 90%. This 2001 report was recognized by WPI with that year's IQP Award for their outstanding work.

Moto Ondoso Reduction Plan:

Moto Ondoso is the wake boats create what they traverse through water. In Venice, Moto Ondoso is problematic because the constant waves crashing into the sides of the canals can deteriorate the structure of the walls overtime. In 2002, the Venice Project Center started their research into Moto Ondoso. They collected data on which boats created bigger wakes and the average speeds that those boats traveled at. They found that most boats go much faster than the speed limits posted and, as a result, Moto Ondoso is significantly increased. If the proposed cargo delivery system from 2001 was implemented they found that Moto Ondoso would also reduce 68%. Likewise, later teams found that if the Taxi System implemented in 2006 was utilized, there would be a 14% reduction. A team in 2015 created a 5-year plan for both of these systems to be implemented along with additional rules about the types of hulls boats can have and stricter enforcement of speeding in the canals.

Boat Traffic Data Collection:

Dating back to 1991, the Venice Project Center has been collecting data on boat traffic and analyzing its effects on canal walls. Actually, the VPC was the first organization to count boats and collect data on the traffic in Venice. Many VPC projects have continued to research boat traffic and its effect on the city. In 2006, the VPC re-engineered the taxi system which accounts for 25% of Venetian traffic. They found that the taxi's do not have passengers over 50% of the time their motors are running. Therefore, they designed a system that would have the taxis move to closer locations after they drop off a customer. This would create less unneeded wake for the city of Venice. Additionally, they created prototypes of possible boat hulls that would be better suited for the low speeds of the Venice canals and create smaller wakes.

Public Art Data Collection and Analysis:

The Venice Project Center started collected data on Venetian public art all the way back in 1990. As the first organization to collect data on these pieces, they paved the way for the methodology and data collection techniques necessary to determine aspects such as, location, current appearance, and cost needed to repair. In 1995, these methods were finalized as the VPC won another IQP award for the team's algorithm for cost of restoration. Additionally, their prioritization system they developed was cited in "Technology Review." Since then, the center has been collecting data and public art all around Venice and working with PreserVenice to keep these pieces in good condition for years to come.

Canal Research:

The Venice Project Center (VPC) started their research on canals back in 1991 and was the first organization to produce organized, sophisticated data on canals. The projects determined the scientific definition of a canal, assigned identification numbers various canal segments which allowed them to be studied to in depth by the VPC in later years. The system worked so well that the City of Venice adopted this numbering system along with some of the data collection methodologies that VPC projects had used to collect its data. Using this data and additional data collected on sewer holes and their damage on canal walls, later projects were able to draw technical conclusions about which canals were in need of more urgent attention by the city. The VPC has always used the most advanced technologies for data management beginning with MapInfo in the early 1990s. In 1999, the Project Center published a book on their 10 years of data collection called <u>Venezia la Città dei Rii.</u>

Appendix E: Sandbox Guide

How to Create a Sandbox Graphic
1. **Select a Graph Type**
   a. Donut Chart: this is a circular chart with empty space in the middle useful for directly comparing the percentages of certain values
   b. Bubble Chart: this is a chart that creates circles with sizes based on the percentage of the data each element encompasses
   c. Bar Chart: this is a chart that compares the raw values of data columns against each other with x and y labels for each axis
2. **Select a Data Set**
   The data sets pull from the Venice Project Center's databases in order to get the most recent data for any particular topic. Currently, the topics available are Bells, Bridges, and Stores. This data has been collected by students from Worcester Polytechnic Institute since 1988, and due to the changing nature of databases since that time, there could be inaccuracies in the data. The Venice Project Center is currently working to fix these inaccuracies.
3. **Select a Data Column**
   The data column is the specific data from the data set that will be visualized. The column names are based off of the raw data, so the names could be very technical.
4. **(Bar Graph) Select a Stacked Data Column**
   The stacked data column is exclusive to the bar graph, and will sort the stacked items based on the values set in the data column. This is useful for categorizing different elements of the data sets.

Graph Settings
1. **General Settings**
   a. Title: The title for the graph
   b. Description: The description for the graph
   c. Font Size: The font size of all elements in the graph. Note: the title is always 2X the font size
   d. Show Legend: Changes the location of the legend (key) on the page. None will hide the key. Note: (Bar Graph) The key will show the stacked element
   e. Hide Outlier Data: Hides Data Sets from the Data Set Selector that have data inappropriate for the currently selected Graph Type
   f. Hide Empty Data: Hides empty values from the current visual. Note: Empty Values are '', ' ', and null
2. **Color Settings**
   a. Font Color: The color for all font in the visual
   b. Coloring Mode
      i. Palette Mode: Chooses 2 Colors and sets each element to a gradient between the 2 colors

   ii. Manual Mode: Allows the user to select a section of the graph and choose a particular color

  c. Other Settings: These are reserved for Graph Type particular settings

Downloading & Uploading Graphics

1. Save Config File: This saves a ".SNDBX" to the user's downloads folder, which contains data for how the graphic is configured
2. Upload Config File: This allows a user to upload a ".SNDBX" file to Sandbox, and upon loading the graphic, the user can continue working on the graphic that had been previously saved
3. Save as PNG: This saves the current Title, Description, Graphic, and Key together as a PNG image file. Note: The key will automatically resize in the image to fit all of its contents

Appendix F: Links to Mentioned Websites

- Venice Project Center 3.0 Website: http://www.veniceprojectcenter.org/vpc
- VPC Instagram: https://www.instagram.com/veniceprojectcenter/
- Sandbox Website: https://sandbox.veniceprojectcenter.org/
- Sandbox Github Repository: https://github.com/vpc30/sandbox
- Timeline Website: https://timeline.veniceprojectcenter.org/
- Timeline Github Repository: https://github.com/vpc30/Venice-Project-Center-Timeline
- Bridge Infographic: https://ponti.veniceprojectcenter.org/bridgestepinfographic
- Bridge Infographic Github Repository: https://github.com/vpc30/Bridge-Height-Infographic
- VPC: Master Project List: https://docs.google.com/spreadsheets/d/1wOAtmhEV57WHfnrX5kLe-BI4Re5L-GnhWi3eCBTT3Ss/edit?usp=sharing
- IQP Label Template: https://drive.google.com/file/d/1N_Rua3A3mpoFTV3jLmoMxKoplXUc0ahZ/view?usp=sharing
- Dashboard: http://dashboard.cityknowledge.net/#/venice