UCCE Composting Education Program Impacts Summary Webpage

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In collaboration with:

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Abstract

This project focuses on developing a webpage for the University of California Cooperative Extension (UCCE) Composting Education Program. The webpage allows users to view a summary of total composting efforts in Santa Clara County, including different statistics and charts, and enter how much they composted, in order to see statistics reflecting the positive environmental impact they made by composting. The webpage will help to motivate people to compost in Santa Clara County by showing the measurable impact they are having by composting and provide a dashboard that summarizes the UCCE Composting Education Program's efforts, in order to justify additional funding. The webpage was written using HTML and JavaScript, using styling from TailwindCSS and JavaScript chart library Chart.js, and deployed using GitHub Pages. The project also involved integration with the UCCE Data team, in order to display the data they organized and stored this quarter. The webpage also promotes composting and rewards composters by providing access to an Augmented Reality (AR) social media-shareable composting experience, which allows composters to interact with and take a picture or video of an Augmented Reality compost pile with grass growing out of it, take a selfie picture or video, and share the pictures or videos on social media to promote their composting efforts. As a result of the project, we learned a lot about how to work with a community partner. This prepares us for future work in industry, when we will also be working on real-life projects with real stakeholders. We have also met all of the requirements agreed on with the UCCE Composting Education Program.

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Ⅰ. Introduction

Our Partner

For our community-based engineering design project, we were partnered with the University of California Cooperative Extension (UCCE) Composting Education Program. This organization works to make composting more accessible to residents of Santa Clara County. The UCCE Composting Education Program interacts with its community primarily by running workshops, offering volunteer opportunities at its demonstration garden, and hosting gardening events. At workshops, they teach the basics of how to compost at home. Their garden demonstration site is the heart of their organization as it brings the community together by providing a location for composters to meet and promote a lifestyle of sustainability. They also have events like fashion shows, plant sales, and festivals which bring the community together.

Background and Motivation

Our partner aims to make composting the norm, wherever possible. Our team's motivation for contributing to this project is the looming threat of the climate crisis. Climate change is a global problem that will require a strong collective effort from all of humanity to solve. While most of the blame is often placed on corporations—and this may be justified—it is also important to recognize the small and simple changes that individuals can make, which, collectively, could have an immense impact.

Although composting can be a privilege granted by location, access to natural resources, and simply knowing *how* to compost, we hope that our partner is able to change that with their composting education programs. Despite the fact that composting is now required by law in California, there are still many municipalities and individuals that haven't adopted any composting methods (and may not even know about the new policy). We hope that our project, though small, will be a step in the right direction in increasing awareness and propelling more people to compost–or continue composting.

User Requirements and Project Specifications

Based on our communication with our community partner contact, Maya Shydlowski, we came up with the following problem statement, which reveals the key involved members and their needs: The UCCE Composting Education Program needs a solution that allows composters in Santa Clara County to see the impact that their composting makes and how much Santa Clara County composts as a whole because the UCCE's composting workshop attendees need motivation to continue composting and the UCCE Composting Education Program needs to be able to show the effects of their work to funders.

Based on the problem statement, we came up with a proposed solution: to create a webpage that shows users a summary of composting efforts in Santa Clara County using different statistics and charts, allows users to enter how much they composted to see statistics reflecting the positive environmental impact they made by composting, and provides access to an Augmented Reality (AR) social media-shareable composting experience that allows composters to interact with and take a picture or video of an AR compost pile with grass growing out of it, take a selfie picture or video, and share the pictures or videos on social media to promote their composting efforts.

Our project has a few objectives. The first is to motivate individuals to compost by providing composters with accurate metrics about the effects of their composting efforts, and a social-media shareable AR composting experience that allows them to showcase their composting efforts on social media. The second is to show tangible data reflecting the impact that the UCCE Composting Education Program has had, by displaying county-wide statistical data collected from UCCE workshop attendees, to show to funders, and also to motivate composters. This allows users to quantify the success of the UCCE Composting Education Program and can be shown to potential donors and used to encourage funding for the organization.

Based on the problem statement, we identified two critical customers for our project. The first is the composting workshop attendees, who will use our product and be motivated to continue composting by viewing evidence of the positive effect their composting has on the environment. Our project improves their situation by allowing them to see the effects of their efforts, through a calculator that converts an amount of composted material into meaningful statistics, such as how many equivalent miles driven by a car worth of CO_2 emissions they saved by composting, as well as charts that show how much composters across Santa Clara County have composted. The AR social media-shareable composting experience also rewards them for their efforts and allows them to showcase their efforts on social media.

The second critical customer is the UCCE Composting Education Program, along with Maya Shydlowski, our primary contact at the organization. Our project improves the UCCE Composting Education Program's situation and solves their problems by enabling them to easily display the impact of the UCCE Composting Education Program's workshops, in order to justify further funding. This is done through charts and statistics showing how much has been composted by workshop attendees across Santa Clara County.

Based on our analysis of our critical customers' needs, determined through conversation with our contact at the UCCE Composting Education Program, and a survey we sent to the composting workshop attendees to find out about what they would want to see in a new webpage for the UCCE Composting Education Program, we came to an agreement on a proposal for our project. We agreed upon the following deliverables for our project with our community partner:

- We will make a website that can be embedded within the UCCE Composting Education Program webpage so that our content will be accessible without linking to a separate website. This will be done through the use of an inline frame (iframe) which is an HTML (Hypertext Markup Language) element that loads another page within the current page.
- The page will have a composting calculator that converts the user's inputted volume or weight of food scraps to CO_2 emissions saved by composting, and also other relevant statistics (for example, equivalent miles driven by car for the same CO_2 emissions, etc.).
- The page will have graphs and statistics summarizing composting contributions across Santa Clara County, based on the data collected from workshop attendees' survey responses. We will receive this data from the Data Team, and if they are unable to provide us with a way to retrieve data from their database this quarter (Fall 2023), we will provide all the necessary code for the graphs to work once the database is connected by next quarter's team.
- The page will have a way for the user to receive a composting badge (Augmented Reality or other) that can be shared on social media, showcasing their composting efforts.

- The page will not send any data to the Data Team's database to be stored. The page will just be a calculator and tool to display the aggregate data from the data team and create a composting achievement badge.

Review of Literature

A more in-depth review of composting yields compelling hard evidence of its benefit to society. Time and again, studies have definitively shown the positive effect of composting on climate change, agriculture, the economy, and more. For example, composting has consistently been shown to save carbon emissions from being released into the atmosphere by sequestering it into soil. A quantitative analysis conducted by researchers from the UCLA Institute of the Environment and Sustainability found there was on average a 46% increase in soil organic carbon levels when compost amendments were used to treat the soil, while another study published by UC Berkeley researchers in the *Scientific Reports* journal found that composting organic materials resulted in 84% lower greenhouse gas emissions when compared to the emissions of equivalent amounts of organic materials that went to the landfill (Bloemsma, C et al., 2020; Perez et al.).

Furthermore, composting can have immense benefits to agribusiness owners and farmers. In a world of deteriorating soil health, composting offers an elegant solution to revitalizing and restoring soil. One 2022 study conducted by Wright et al. in the *Open Journal of Soil Science* found that composting amendments significantly increased soil porosity, water capacity, and microbial biomass, all of which led to higher crop yields and improved soil health. Not only is this better for farmers, as they can harvest more crops, it is also better for consumers who desire high-quality organic food.

If the aforementioned reasons are not enough to lead to someone supporting composting, there is also evidence that composting benefits society economically. If less food waste and other organic materials go into the landfill, and are instead composted, businesses and individuals alike can save lots of money on landfilling fees. Not to mention, composting means utilizing resources in a circular manner that makes the most out of scarce resources. A study published in the *Environ Health Insights* journal projected that increasing the U.S.’ compost to waste ratio by just 8% would lead to $16 billion USD in waste management savings (Farhidi, Madani, Crichton, 2022). Businesses can tap into these savings as well. The Mariners’ Safeco Field, for example, saved over $130,000 in one year by composting (as opposed to landfilling) 85% of stadium food waste (Josephson, 2023).

The high impact of composting, as evidenced by various papers and research studies, makes our project even more meaningful. If we can motivate more people to compost, then we have successfully made a positive impact on the environment, economy, and individuals' lives.

Report Roadmap

The bulk of the report focuses on discussion of the project, including in-depth project specifications, as well as civic considerations for the project, and a results and analysis section containing more of the technical details of the website and the completed final product. Towards the end of the report we reflect on the project in the conclusion section. We also include an appendix section, with additional information, including details for future teams that may be in charge of updating the project, or a member of the UCCE in charge of maintaining it.

Ⅱ. Discussion

Project Specifications

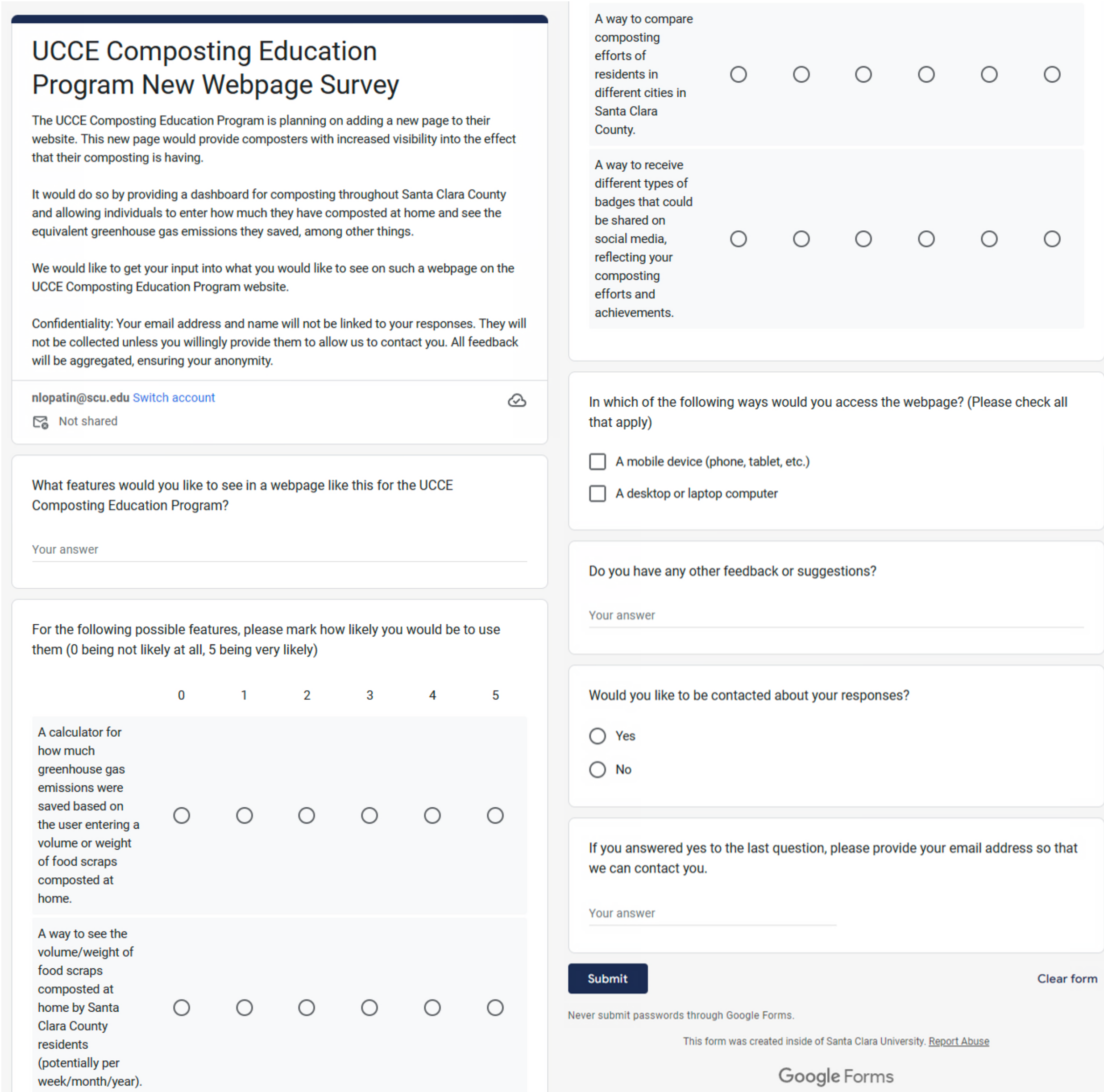
There were many discussions over project specifications that needed to take place over the course of the project, specifically in the design phase. The first step was to talk to our contact, Maya Shydlowski, at the UCCE about the framework of their website. We discovered that they used a site builder that was created by the University of California Division of Agriculture and Natural Resources (UCANR). After further discussions, we were told that they would not be able to give us access credentials due to privacy concerns, specifically that only internal personnel have the ability to modify the official website.

From here, we considered various other solutions such as an iOS app, Android app, or website. We evaluated the benefits and drawbacks of each option and ultimately landed on the idea of a website because it is accessible on many types of devices (laptop, tablet, cell phone), in addition to the fact that we would have the ability to easily embed our website within the UCCE's using an iframe. Our website was deployed through the use of GitHub pages, a free online hosting service that has allowed us to develop the calculator and its functionality without needing direct access to the UCCE website builder.

Another discussion we had with our contact surrounded the specifics of what exactly our calculator should return. These conversations were very insightful and gave us a better understanding of what the UCCE was looking for. Maya also provided us with a sample calculator from the EPA which converted energy savings into various metrics. This was helpful because it allowed us to access conversion factors that we could eventually implement into our calculator (US EPA).

One constraint we ran into was the collaboration with the UCCE Data Team. The Data Team is another group of Santa Clara University students, working in collaboration with the UCCE Composting Education Program. Our projects are closely intertwined due to the fact that we needed to receive aggregate county-wide data that their group collected, in order to access the survey response data from workshop attendees. We initially believed that users would input data on our website, and then we would send that data to the Data Team's database. This would require a very intensive solution and a lot of cooperation between the two teams. After discussing with both the data team and our contact, we learned that we would only need to retrieve data from the database, and not append to it. However, the intertwined nature of our projects still made it difficult for us to manage the timeline of the project, as some specifications of our project depended on the Data Team's project being complete. For example, we could not create accurate charts on our webpage, populated with real data, until the Data Team had figured out a place to store the data and also had created an endpoint for us to fetch data from with HyperText Transfer Protocol (HTTP) requests. Our team agreed with the data team that an Application Programming Interface (API) would be the best way to do this. An API can be thought of as a function that is called over the internet: the client calling the API specifies the data that they want in the header of the HTTP request, and the API then returns that data. In our case, the data that we request is the various composting statistics that we want to display on our website.

One helpful tool that we used to find out more about what composters who had gone to workshops run by the UCCE Composting Education Program wanted to see in a new webpage for the program was a survey that we sent to our partner to send to the composting workshop attendees. It asked what features they would like to see in the webpage, how likely they would be to use different solutions that we had discussed with our partner, whether they would access the webpage on mobile or desktop, and if they had any other feedback or suggestions.



UCCE Composting Education Program New Webpage Survey

The UCCE Composting Education Program is planning on adding a new page to their website. This new page would provide composters with increased visibility into the effect that their composting is having.

It would do so by providing a dashboard for composting throughout Santa Clara County and allowing individuals to enter how much they have composted at home and see the equivalent greenhouse gas emissions they saved, among other things.

We would like to get your input into what you would like to see on such a webpage on the UCCE Composting Education Program website.

Confidentiality: Your email address and name will not be linked to your responses. They will not be collected unless you willingly provide them to allow us to contact you. All feedback will be aggregated, ensuring your anonymity.

nlopatin@scu.edu Switch account

Not shared

What features would you like to see in a webpage like this for the UCCE Composting Education Program?

Your answer

For the following possible features, please mark how likely you would be to use them (0 being not likely at all, 5 being very likely)

	0	1	2	3	4	5
A calculator for how much greenhouse gas emissions were saved based on the user entering a volume or weight of food scraps composted at home.	○	○	○	○	○	○
A way to see the volume/weight of food scraps composted at home by Santa Clara County residents (potentially per week/month/year).	○	○	○	○	○	○
A way to compare composting efforts of residents in different cities in Santa Clara County.	○	○	○	○	○	○
A way to receive different types of badges that could be shared on social media, reflecting your composting efforts and achievements.	○	○	○	○	○	○

In which of the following ways would you access the webpage? (Please check all that apply)

- A mobile device (phone, tablet, etc.)
- A desktop or laptop computer

Do you have any other feedback or suggestions?

Your answer

Would you like to be contacted about your responses?

- Yes
- No

If you answered yes to the last question, please provide your email address so that we can contact you.

Your answer

Submit

Clear form

Never submit passwords through Google Forms.

This form was created inside of Santa Clara University. Report Abuse

Google Forms

Figure 1. UCCE Composting Education Program New Webpage Survey

Although the survey was not sent out immediately after we provided it, since the UCCE Composting Education Program had a delay in getting their weekly email sent out because a volunteer forgot to send the attendance sheet for it, the results we got reflected that all of the solutions we had proposed were desired by the users, and that users would use the webpage on both desktop and mobile.

Civil Considerations

Throughout the development of our project for the UCCE Composting Education Program, it has been important to take into account governmental, ethical, and community standards. These laws, practices, and expectations are critical in creating a product that upholds moral values set forth by both the University and the UCCE and ensures a positive impact on the community we are working with.

The main organization that plays a role in the public policy problems raised by our project is the UCCE. During our project's development, we had to ensure that we did not disclose any personally identifiable information, and we worked closely with our partner to ensure that we handled the information we had access to in a way that our partner was comfortable with. Additionally, composting is not yet a widespread practice, despite evidence that it has many positive effects on the environment and nearby communities. The United States Environmental Protection Agency estimated in 2019 that of the 66 million tons of food waste that year, only about 5% of it was composted (Food: Material-specific Data, 2023). The UCCE Composting Education Program aims to make composting the norm. Its mission is to educate the community about composting (Composting Education - Santa Clara County) and support Santa Clara County residents in diverting household organic waste (UCCE Programs). Its goal is to decrease the amount of organic waste sent to landfills and encourage the use of compost in gardens and landscapes (UCCE Programs). Through its workshops, the UCCE Composting Education Program has an impact on local communities by educating them about composting. To increase the UCCE Composting Education Program's impact, a solution was needed that could display digestible metrics showing the impact of the program, with the intention of impacting public policy regarding composting.

Ⅲ. Results and Analysis

Final Specifications

After multiple synchronous meetings and several offline communications with our partner, we were able to derive the full project specifications—the critical functions of the website, the scope of our side of the project, the scope of the data team's side of the project, and the integrations between our teams. For the website, the critical features include:

- The ability for our website to be embedded into the UCCE Composting Education Program website via an inline frame
- Mobile and desktop compatibility, with a focus mostly on mobile devices (based on knowledge of the critical customers)
- A calculator component that allows the user to input how much they composted, in four different units (pounds, kilograms, gallons, or liters), and converts that input to useful statistics, such as the equivalent kilograms of CO_2 saved by composting that amount, or the percentile of composters that the person was in (see Figure 2 for all statistics)
- A display of aggregate UCCE composting data. For instance, a pie chart of the total yard waste to food waste ratio and a histogram of community members' weekly composting quantities
- A way to access the AR social media-shareable composting experience

Final Product

When the user first visits the UCCE Composting Education Program's new webpage they see our webpage embedded in the UCCE Composting Education Program Website (Figure 2 below).

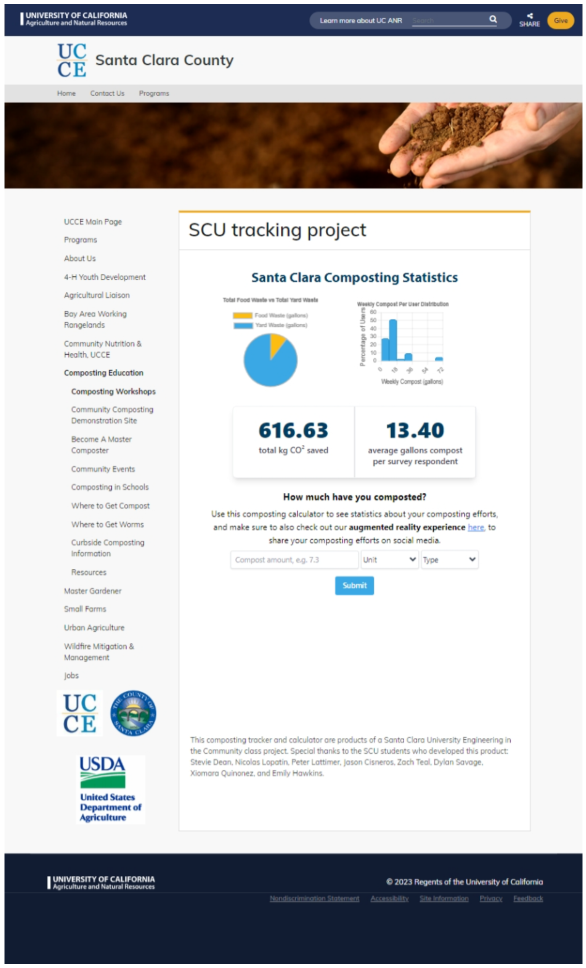


Figure 2. Our Webpage Embedded in the UCCE Composting Education Program Website

At the top of our embedded page, they see the UCCE Composting Education Program's aggregate statistics for Santa Clara County (shown larger below on the left side of Figure 4 below). In order to see individual statistics, the user can enter in how much he or she composted, the units of measurement, and what type of compost—food waste or yard waste (see Figure 3 below). After pressing submit, the individual statistics are displayed (right side of Figure 4 below). Also visible in Figure 3 is the link to the AR social media-shareable composting experience that was created for the project.

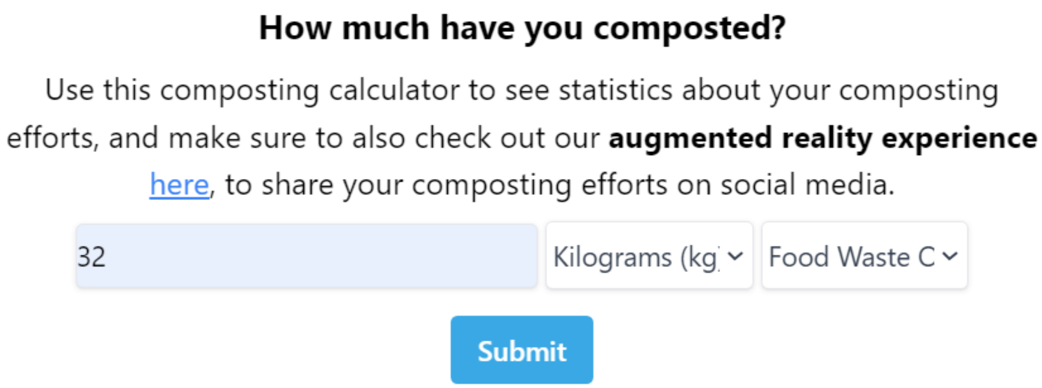


Figure 3. Composting Calculator and Link to AR Experience on our Website

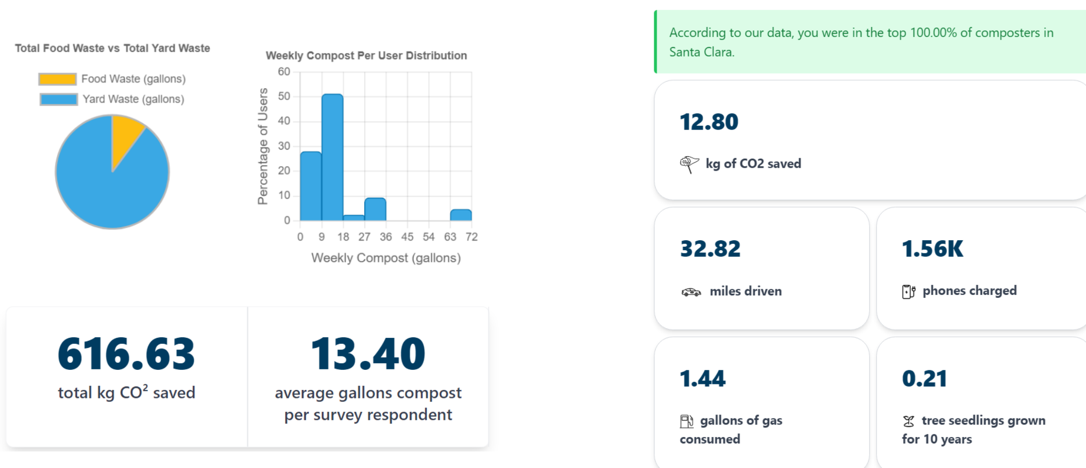


Figure 4. Aggregate (left side) and Individual (left side) Statistics on our Final Webpage

Below (Figure 5 and Figure 6) are some initial mockups of our website, made with Figma, a popular tool used for user interface development. Note the vertical alignment of elements on the mobile design, and the horizontal grid alignment on the desktop website. One can easily see the resemblance between the mockups and the final product in Figure 2.

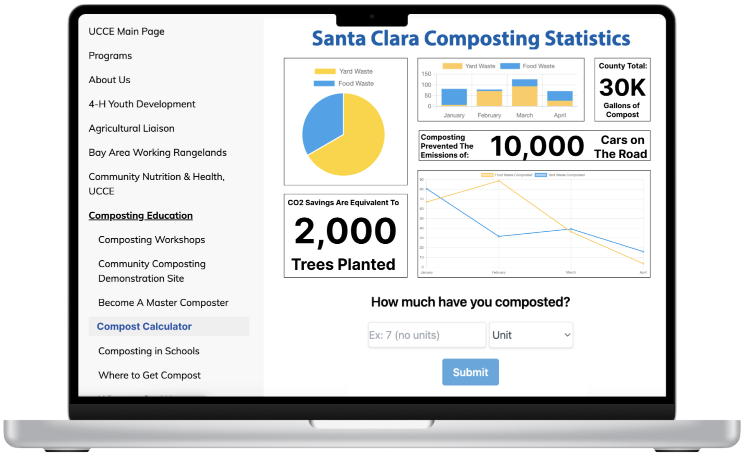


Figure 5. Desktop website mockup

Figure 6. Mobile site mockup

We also implemented a feature to reward composters: an AR social media-shareable composting experience that allows composters to interact with and take a picture or video of an Augmented Reality compost pile with grass growing out of it, take a selfie picture or video, and share the pictures or videos on social media to promote their composting efforts.

The augmented reality experience can be accessed by clicking on the link shown in Figure 3. On a mobile device this brings users to the experience immediately. On a desktop device, this displays a QR code, which can then be scanned on a mobile device (Figure 7).

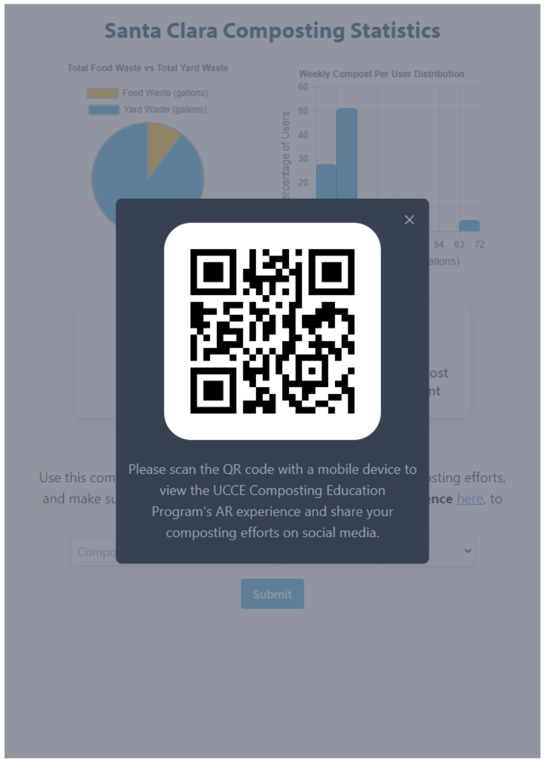


Figure 7. Pop-up modal box triggered by pressing the AR experience link

After the page loads, users have to grant permissions to use the camera and motion sensors for the AR experience to work, and then they are taken to the Augmented Reality View, which displays a compost pile with grass growing out of it (Figure 8). The grass sways gently in the wind, and users can take a picture or video using the built-in capture functionality. They can then share the picture or video on social media (Figure 8).

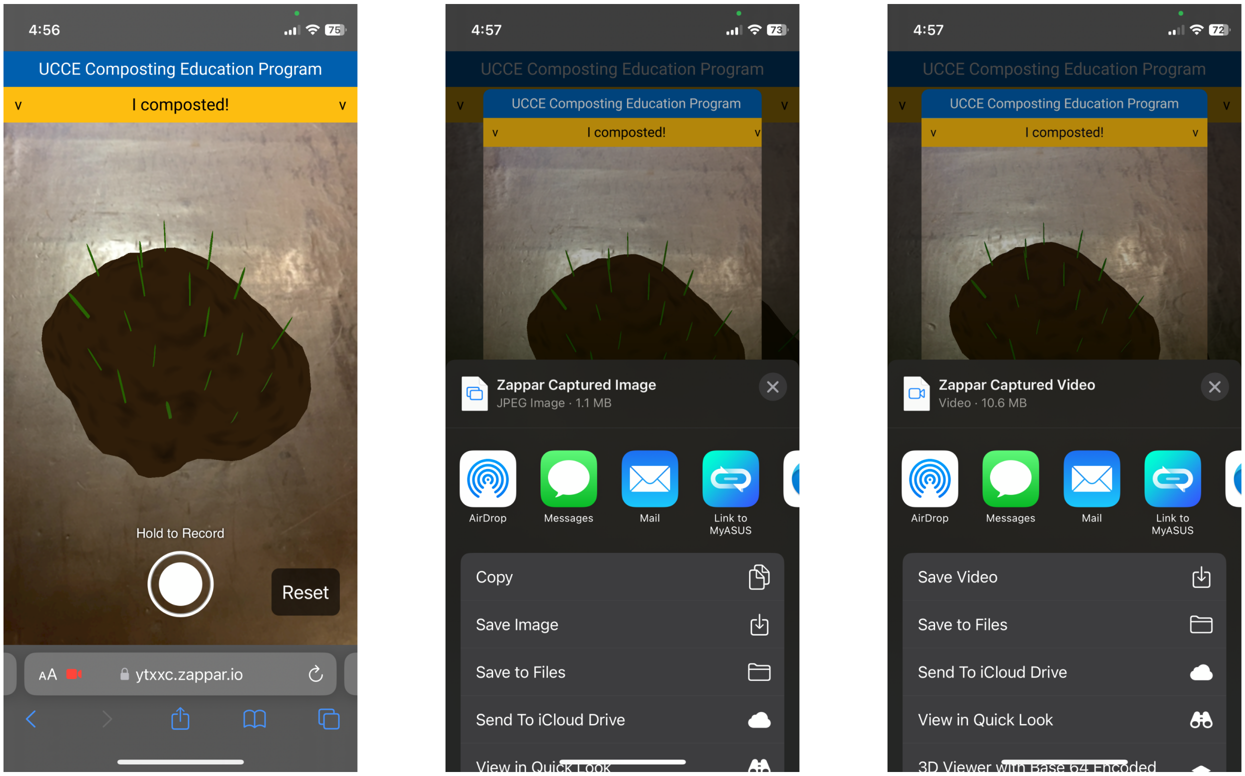


Figure 8. Augmented Reality View (left) and Image and Video Sharing Ability (middle and right)

From Augmented Reality View, the user can switch to Selfie View using the dropdown option. In Selfie View they can also take a picture or video and share it on social media, just like in Augmented Reality View. In Selfie View, they can also switch back to Augmented Reality View (Figure 9).

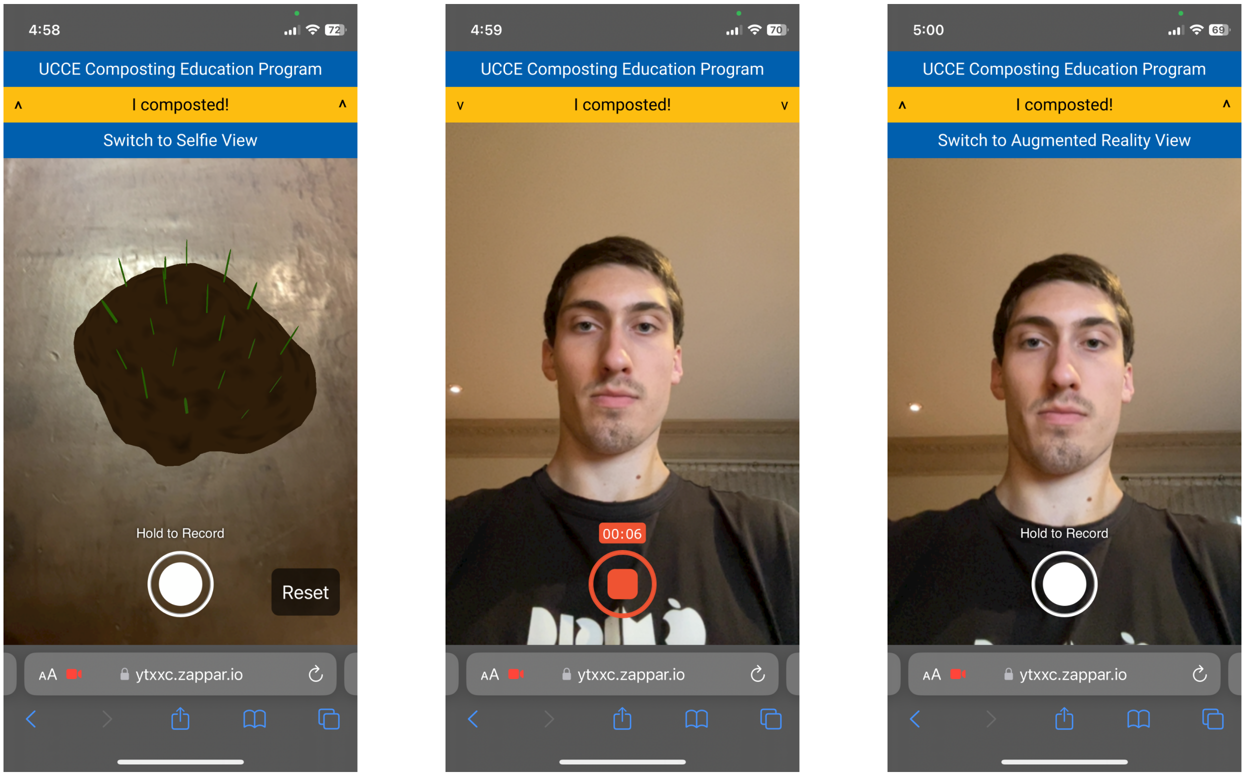


Figure 9. Switching to Selfie View (left), Selfie View (middle), and Switching to Augmented Reality View (right)

The experience can be found here (on mobile), or using the QR code in Figure 10, below.

Figure 10. QR Code to Access AR Experience

The AR experience is built using WebAR, a technology that allows for the widest variety of mobile devices to access the experience, as it is run in the mobile device's browser, and is powered by Zappar, an industry-leading AR studio.

Challenges

Although our original understanding of the project was that UCCE Composting Education Program's current composting data collection method (Qualtrics) might be replaced by our composting data website, we discovered later on that this was outside of the scope of our project (as well as the data team's project), but could be a potential project for future ENGR 110 students.

In regards to our integration with the data team, our main endpoint for interacting with them was Google Sheets, which offered a free solution for us to pull anonymized aggregate composting data using the Google Sheets API. Previous discussions of connecting our teams through other technologies such as Amazon Web Services could create issues with future maintenance of the project, as it would require significant programming knowledge, ultimately leading the data team to use Google Sheets.

Full details of the website implementation, including the code specifications and instructions for future use, can be found in the appendix.

Budget

In terms of the budget for our project, we had a $100 budget allocated for our project. Due to the nature of our project and the free tools that we used, this was not necessary and we completed the project without spending any of our budget.

Technical Implementation Details and Testing

Our project had two different scopes of testing. Firstly, our web application needed to work from a technical perspective. This means that it needed to work intuitively, provide accurate results, and have an appealing user interface. In order to test that our website met this criteria, we used various testing techniques to evaluate each metric.

When it comes to user input, we focused on extensive testing, including extensively testing edge cases. For example, if a user does not select a unit for the amount that they composted, we provide an error message prompting them to provide a unit so we can make accurate calculations. Likewise, if they do not enter an input, they get a similar error message. We have also limited the inputs so that users are only able to input decimal numbers.

In terms of accuracy, our calculations are based on a formula that was provided to us by the UCCE through our contact, Maya (1 pound of organic waste composted = 0.1814 kg of CO_2 saved). Once we received this formula, we compared it to the formulas that we attempted to develop ourselves. Since we are calculating CO_2 savings, there are various ways to do the math given that there are different things (compost wetness, compost processing techniques, etc.) you can take into account. After analyzing the formula they provided to us, we found that it closely matched with the findings of different research papers that we analyzed related to composting and saving CO_2 emissions (Nordahl et al; Blengini). Thus, we are confident that we are providing users with accurate results.

Another metric we used to test our website was accessibility. It was really important to ensure that the final product we provided to the UCCE is inclusive and accessible to all users. One way that we tested this criteria was by downloading a screen reader and using our website from the perspective of someone who needs this technology to interact with the internet. We found a couple of areas of our website, mainly our graph components, which needed additional alternative text (which the screen reader uses to read the website). After we were able to identify this lack of accessibility, it was a quick fix to add in the alternative text that made our website much more inclusive for our users.

Additionally, our website also had to meet the standards that we agreed upon with the UCCE Composting Education Program. During the design portion of our project, we communicated with Maya regarding the UCCE Composting Education Programs's desired functionality and listed out the requirements for the website as mentioned in section I. In terms of testing whether the website meets the needs of the UCCE, it was important to evaluate each of these relevant features. Our final product meets all of the original requirements we had agreed on.

First, the UCCE Composting Education Program requested a composting calculator. We successfully implemented the composting calculator which converts the user's inputted value of compost to CO_2 savings, based upon the formula provided to us by the UCCE. Second, the UCCE Composting Education Program requested that we find a way to display larger data sets based on survey responses from composting workshop participants. We created functionality to use the UCCE Data Team's Google Spreadsheet and display aggregate county-wide composting statistics. Third, the UCCE Composting Education Program requested that our product be accessible to their community through their website. When creating our project, we used GitHub Pages to host our website, which allows the UCCE to integrate it into their website using an iframe component. Finally, our project includes an AR social media-shareable composting experience that provides users with badges that they can share on social media, as agreed on in our specifications. Based on the criteria and agreements we made with Maya Shydlowski and the UCCE, we believe that we successfully created a project that meets and exceeds their standards.

The technical testing and evaluation phases of our project were highly valuable because they allowed us to identify areas of the project that needed additional attention and consideration. Looking back, these improvements were critical to delivering a product that not only met the requirements of the UCCE but also provided all users with a good experience when interacting with our website. Overall we are pleased with the success of the project, and we believe the final product delivered will ultimately benefit the UCCE community.

Ⅳ. Conclusion

Overall, our partnership with the UCCE Composting Education Program has led to the development of a robust solution aimed at fostering a culture of composting within Santa Clara County. Our project was guided by the fundamental objective of providing tangible evidence and motivation to individuals engaging in composting, while also providing the UCCE Composting Education Program with essential data to substantiate their efforts to potential funders. Our initiative was not merely a technical endeavor; it was deeply rooted in a broader societal context. Composting, despite its proven benefits, has yet to attain widespread adoption. By empowering the UCCE Composting Education Program with a tool to showcase the impact of their educational programs, we sought to contribute to larger policy discussions regarding waste management and environmental sustainability.

Going forward, we hope that other students in future ENGR 110 classes will be able to build on the project that we started. Throughout the development of our project, we were intentional about following best practices and making our code readable so that other students would be able to continue the project. Perhaps in the future, there will no longer be a Qualtrics form for UCCE Composting Education program participants, and the entire data collection process will happen on our embedded website. Given our time constraints, we are proud of what we accomplished, and we look forward to seeing how our partner will be able to effectively use the new website.

Ⅴ. Appendix

Tips for Website Maintenance

As in the case of any software-related project, it is critical for us to provide documentation for potential future developers and maintainers. In the appendix, we give a thorough guide intended for developers working on the website, as well as for anyone who may want to make simple changes, such as changing a graph, statistic, icon, etc.

General Notes

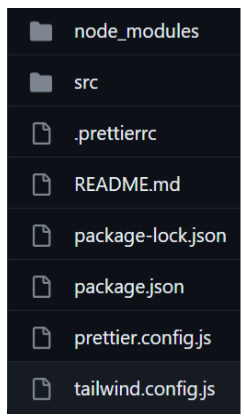


Figure 1. Files in the root directory of the project

Upon looking at the root directory of the project, one will see 6 files and 2 folders, as shown in Figure 1. While the bulk of the project is in the /src/ directory, as the name of the folder would imply, there are important files here in the root. The README.md file is a high-level overview of the project, and not something to worry about. The two config files for Tailwind and Prettier are more important. TailwindCSS is the styling library that we used for creating the website's CSS, and it is crucial for future developers to understand how it works before proceeding with any work on the visual elements of the website. Thankfully, most developers will likely find it highly intuitive and prefer it over normal CSS. TailwindCSS combines HTML and CSS such that developers will hopefully never have to touch a .css file when developing a website. To style elements, developers can use Tailwind's utility classes, which usually map directly to a CSS attribute (see Figure 2).

```
<div class="relative bg-white rounded-lg shadow bg-gray-700">
```

Figure 2. Example of using Tailwind utility classes in HTML

In this example above, we use the classes “relative bg-white rounded-lg shadow bg-gray-700” to style a div, where relative corresponds to position: relative, bg-white corresponds to background-color: rgb(255 255 255), rounded-lg corresponds to border-radius: 0.5rem, and so on. When Tailwind sees that we have used these utility classes (an extensive list of which can be found in TailwindCSS documentation), it will automatically generate the corresponding CSS classes in the CSS files specified in tailwind.config.js. In developing this website, we found that using TailwindCSS required much less typing and made it especially easy to define behavior across different breakpoints. For example, if we wanted to define that a certain element should have a white background on medium size devices or larger, we would write md:bg-white for the class. Please reference the Tailwind documentation for more information. We highly recommend using the Tailwind library, but if you would rather use something else, you can simply keep the code as is, and make sure to keep all the classes in the file \src\styles\tailwind.styles.css. Deleting the tailwind.styles.css file will get rid of all the styles that are currently used on the website, so we would strongly advise against it.

The other files in the root directory of the project are all related to Prettier, which is a code formatter and also has a node module extension for formatting the precedence of TailwindCSS utility classes. Prettier is relatively simple to use, and more instructions on using it can be found on the Tailwind website as well as the Prettier website. If you would rather use a different code formatter, you can simply delete the node_modules directory, .prettierrc, package-lock.json, package.json, and prettier.config.js files.

In the src directory, one will find all of the files for the website, which are neatly organized into different folders. The structure is self-explanatory: the images folder contains all of the images and icons to be displayed, while the pages folder contains the .html file for the homepage, scripts contains the home.js file, which is the JavaScript for the homepage, and styles contains the CSS files generated by Tailwind. This guide will focus on the .html and .js files for the website, as they are where the functionality of the website lies.

In the home.html file, one can find the barebones of the website, which is broken up into divs, such as in Figure 3.

```html
<div
  class="tablet:flex tablet:justify-between mx-auto mt-4 w-4/5 md:w-3/5"
  id="statistics-container"
>
  <div id="left-flex-container" class="tablet:w-[42%] relative md:w-[35%]">
    <canvas id="pie-chart" aria-label="Chart 1"></canvas>
  </div>
  <div
    id="right-flex-container"
    class="tablet:w-[49%] relative mt-2 md:ml-4 md:w-[65%]"
  >
    <canvas aria-label="Chart 2" id="bar-chart"></canvas>
  </div>
</div>
```

Figure 3. Div containing the Chart.js charts

These divs help to organize the content on the page and should make it easier for developers to manage. At the top of the page is the header for the website, as well as the div with the charts. One particularly important part of the header is the Google Sheets API, because it triggers the handleClientLoad function in home.js when it loads. Below that are a couple of divs for the pop-up modal dialogue which is triggered when a user presses the link to open the AR experience. At the bottom of the page is the composting calculator and all of the individual statistics. The individual statistics are placed into the div with id “user-input-content,” so we recommend to not delete this part of the HTML. Be sure to also check the JavaScript files when you are changing the id of an HTML element, as the ids are used frequently within the JS to access certain elements.

Even more important than home.html is home.js, where all of the inputs and charts are handled. We have ordered the functions such that the major functions are near the top of the script, and less important or helper functions are near the bottom. Thus, we see at the top some constants for icons that are used on the page, as well as the function that is called whenever a user presses the submit button. In this function, we first check for bad inputs by using a regex expression. If there are any bad inputs (for example, characters), we do not go any further. Otherwise, we convert whatever their input was into kilograms of CO_2, as that is the unit required when calculating the other statistics (miles driven, etc). These calculations are separated into helper functions. We also calculate the user’s percentile (separate function), and finally, we put all of these statistics into the statistics containers that are displayed on the website. Since each statistic container is roughly the same, we've moved the functionality into a helper function, similar to how components are represented by functions in a web framework like React. This way, it should be easy to change the design of the container.

The toggleAR function is called when the user presses the link to open the AR experience, and although it may look a bit complicated, it is actually quite simple. There is a long regex expression to check whether the device is mobile or not, and if it is, we open the link directly, but if not, we toggle the modal dialogue as mentioned earlier and include an opacity transition.

Altering Charts

Because the charts are one of the most important functionalities of the website, we have separated the discussion of them into a distinct section. Our charts are currently powered by Chart.js, a popular Javascript framework for creating HTML charts. The Chart.js documentation provides various different guides for creating all sorts of charts and graphs. Making small changes to the charts is fairly easy.

```
const pieChartElement = document.getElementById("pie-chart").getContext("2d");
new Chart(pieChartElement, {
  type: "pie",
  data: {
    labels: ["Food Waste (gallons)", "Yard Waste (gallons)"],
    datasets: [
      {
        labels: [],
        data: [totalFoodCompost, totalYardCompost],
        borderWidth: 2,
        borderColor: "#b8b8b8",
        backgroundColor: ["#fdbd10", "#3aa8e4"],
      },
    ],
  },
  options: {
    plugins: {
      title: {
        display: true,
        text: "Total Food Waste vs Total Yard Waste",
      },
    },
    responsive: true,
    aspectRatio: 1,
    maintainAspectRatio: true,
  },
```

Figure 4. Code for creating a Chart.js chart

As seen in Figure 4, the structure of a Chart.js chart is fairly simple. Most important for the chart is the datasets. Depending on the type of graph, the type of data passed in might be different. The labels and titles are quite easy to change, as they are obvious in the code. It is also important to note the aspect ratio for the charts. We found empirically that the charts will look quite different on small/medium/large screen sizes if the aspect ratio is something other than 1, which is why we check the width of the device to change the aspect ratio in case it is something other than 1, for the histogram (not pictured in Figure 4). The smaller the screen size, the more compressed the graph and therefore the smaller the aspect ratio, we found on average.

```
bigStatsContainer.innerHTML = `<div class="mt-10 pb-3">
    <div class="relative">
      <div class="absolute inset-0 h-1/2"></div>
      <div class="md:max-w-[75%] tablet:max-w-xl relative mx-auto px-4 sm:px-6 lg:px-8">
        <div class="mx-auto md:max-w-[75%] tablet:max-w-xl">
          <dl class="rounded-lg border-[1px] border-gray-100 bg-white shadow-lg sm:grid sm:grid-cols-2">
            <div
              class="flex flex-col border-b border-gray-200 p-6 text-center sm:border-0 sm:border-r"
            >
              <dt
                class="order-2 mt-2 text-lg font-medium leading-6 text-gray-700"
                id="item-1"
              >
                total kg CO2 saved
              </dt>
              <dd
                class="order-1 text-5xl font-extrabold leading-none text-anr-off-blue"
                aria-describedby="item-1"
              >
                ${totalCO2Saved}
```

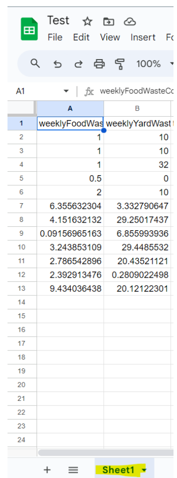
Figure 5. Code for the big statistics container below the graph, also shown

The code for the large statistics container below the Chart.js charts on the website, as seen in Figure 5, is fairly easy to change as well. The main things to pay attention to are the ${totalCO2Saved} and the text slightly above it within the <dt> tag, where totalCO2Saved is the variable passed into the function that represents the number to be displayed, and the text in the <dt> tag is the description below the number. The code for the second statistic (in this case, average gallons of compost per survey respondent) is right below the code for the first statistic, and functions exactly the same.

What is also important for the Charts is the data grabbed from Google Spreadsheets, which happens inside the loadSheets function.

```
function loadSheets() {
  const spreadsheetId = "1a2lu7WKtuDUc8pVww3tYwzoSUcgwdtpoWC1CxdEGaoI";
  const sheetName = "Sheet1";
```

```
docs.google.com/spreadsheets/d/1a2lu7WKtuDUc8pVww3tYwzoSUcgwdtpoWC1CxdEGaoI/edit#gid=0
```



	A	B
1	weeklyFoodWas	weeklyYardWast
2	1	10
3	1	10
4	1	32
5	0.5	0
6	2	10
7	6.355632304	3.332790647
8	4.151632132	29.25017437
9	0.09156965163	6.855993936
10	3.243853109	29.4485532
11	2.786542896	20.43521121
12	2.392913476	0.2809022498
13	9.434036438	20.12122301
14		
15		
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Figure 6. Spreadsheet ID/name vs the actual Google Spreadsheet

As shown in Figure 6, the most important information necessary to use the Google Sheets API is the spreadsheet ID (the highlighted section of the link in Figure 6), and the individual sheet name (highlighted at the bottom of Figure 6). This tells the API exactly what information we want to grab. We can then use the Google API script included in the header of home.html, to call the API, as shown below in Figure 7.

```
gapi.client.sheets.spreadsheets.values
  .get({
    spreadsheetId,
    range: sheetName,
  })
  .then(
    function (response) {
      const values = response.result.values;
      totalFoodCompost = values[1][2];
      totalYardCompost = values[1][3];
```

Figure 7. Call to Google Spreadsheets API

The Google Spreadsheets API will return a 0-indexed matrix from which we can then parse our data, format it, and create charts. However, one important thing to note is that in order to call the Google Spreadsheets API from the frontend, the spreadsheet we are attempting to access MUST be publicly accessible (i.e. sharing settings set to “anyone on the internet with the link can view”). Reading the Google Spreadsheets documentation will further help explain this. Essentially, the only way to access a non-public Google Spreadsheet using only JavaScript is to have a user login using an OAuth client, and then the website can display whatever spreadsheets that user has permission to view. We cannot, therefore, use service accounts on the frontend to access the spreadsheets we want to use, and from a design standpoint, it probably doesn’t make sense for Google to allow that either.

In the future, teams that would like to maintain this website but keep the spreadsheet private could set-up a proxy API, which accesses the spreadsheet using special credentials (e.g. a service account), and have the front-end call that API for the necessary data. Accessing the spreadsheet from a server context is quite easy if one follows the Spreadsheets API documentation.

Some readers might notice that to calculate the percentile requires data from localStorage, which is set when the Spreadsheets information is retrieved. Hypothetically, it is possible that a user submits input to the calculator before said spreadsheet's information (which is necessary to calculate the percentile) is retrieved. While we think in practice it is impossible for this to happen, since the spreadsheets call is very fast, it is an edge-case that future teams may also want to consider.

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