

Creating A Searching Tool for Finding Global Partnerships



WPI

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    <div class="col-md-6 col-lg-8"> <!-- _____ BEGIN NAVIGATION
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Creating A Searching Tool for Finding Global Partnerships



An Interactive Qualifying Project Report

Submitted to:

The Faculty of Worcester Polytechnic Institute
in partial fulfillment of
the Bachelor of Science Degree

Submitted by:

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Abstract

Despite Taiwan having an excellent educational system that fosters growth, discipline, and high performing students, students are not developing critical thinking skills within their curriculum. To counteract this, the Taiwanese startup organization Twin Oaks Education has created the *See Think Wonder* Challenge to help students develop critical thinking skills. Twin Oaks needs to identify potential partners in other regions to spread the challenge throughout the world. In collaboration with Twin Oaks, we developed a partner searching tool to help them identify suitable partners to expand the *See Think Wonder* Challenge. The deliverables consisted of the formation of a user interface, integration with Google's Custom Search API, a website user manual, and a training seminar to demonstrate the website's searching capabilities.

Acknowledgements

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- The Taiwan Project Center Directors: Professor Wen-Hua Du and Jennifer Rudolph, for providing us with this project, allowing us to connect with our sponsor, and for spending their time and effort orchestrating travel to Hawai'i after Taiwan was closed to our group during the COVID-19 Pandemic.
- The Taiwan Project Center Advisors: Professors Grant Burrier and Melissa Butler, for consistent feedback on our project and for hosting events during our time in Hawai'i. Their feedback helped to improve this project, this report, and taught us the skills for operating in a project-focused environment.
- Most importantly, our sponsor Maggie Lin and her organization, Twin Oaks Education, for connecting with our group for this project, and for working with us through the project's virtual environment. Their consistent support and feedback on all stages and iterations of this project created a functional, complete, and high-quality searching tool.

Executive Summary

The 21st century depends on individuals attaining high-ordered skills such as collaboration, creativity, critical thinking, and problem solving (Evan Laar, Ester, et al 2020). Critical thinking skills are desirable in the job market, but there have been talent shortages recently. Approximately 69% of companies around the world report talent shortages and difficulty hiring individuals (ManpowerGroup, 2021). A survey regarding talent shortages among 39,195 employers in 43 countries has seen regions such as Japan, Hong Kong, Singapore, and India among the top ten most affected markets (ManpowerGroup, 2018).

Talent and critical thinking skill shortages are seen in countries like Hong Kong and Singapore that follow the EAEM (East Education Model). These countries use the Assessment for Learning (AFL) strategy to test individuals' knowledge through formative assessments. The emphasis on assessments creates a high-pressure environment with a focus on rote memorization and retaining information on a surface level. This pedagogy has the negative consequence of encouraging students to deprioritize understanding and comprehending information at a deeper level (Johanns, 2017; Klenowski, 2009).

According to the Hong Kong Curriculum Development Council (CDC), the Hong Kong Examinations Assessment Authority (HKEAA), and the Education Bureau (EDB), “[Examinations] had accelerated competition for the highest grades in an already highly competitive environment.” (James and Mary, 2017). This emphasis on grades focuses the curriculum on student performance, resulting in teachers teaching students for the test, as opposed to understanding the subject. Consequently, the assessment-oriented curriculum places little emphasis on critical thinking.

Twin Oaks is a start-up, non-profit organization that promotes critical thinking to supplement skills that are not taught in schools. Twin Oaks has the online *See Think Wonder* challenge, which is a program that enables students to tackle real-life problems and create solutions. In 2021, they launched their pilot program in Taiwan to encourage students to make careful observations and interpretations. However, given that Twin Oaks is a new organization, they are looking to grow and expand their challenge all over the world by finding regional partners willing to spread their *See Think Wonder* Challenge. The goal of this project is to develop a partner searching tool that allows Twin Oaks to find partners. To achieve this goal, the team produced four deliverables:

1. Designed the “back end” of the searching tool and website that allows the tool to communicate with Google’s Programmable Search Engine and Custom Search API.
2. Developed and implemented an interface that Twin Oaks employees can use, regardless of computer skill level.
3. Developed a user guide to help explain the functions and operating instructions of our website.
4. Hosted a presentation workshop on the searching tool for Twin Oaks employees.

The first step we took to develop the searching tool was to identify our search criteria. These search criteria are words that identify an organization as a potential partner and filter out unsuitable or irrelevant partners. Organizations with these search criteria on their web page would be identified as potential partners to market the *See Think Wonder* Challenge.

After finding the search criteria, our team used Google’s Custom Search API to refine search results. We created a JavaScript application to directly communicate with the API. This JavaScript application retrieves the hyperlinks of each organization’s website and descriptive

text about the website. In addition, the team used JavaScript, HTML, and CSS to develop a user interface as a functional website that enables Twin Oaks employees to interact with Google's Custom Search API. The first low-fidelity prototype of the website was done in Google Slides to simply demonstrate the look and inputs to our user interface. The next step was programming an operational low-fidelity prototype that allowed a fully-interactable and varied demonstration that showed real-time, albeit imperfect search results (Figure 1). The team designed a high-fidelity prototype to include aesthetic designs and stylistic choices. The final interface includes numerous features to streamline and improve the experience of the users (Figure 2).

Twin Oaks Education

Input Parameters

Add Key Words / Phrases:

Here are the key words to be searched

- Learning
- Outreach
- Critical Thinking

Add Search Criteria:

Location:

Is This an NPO?

Target only high school students?

The organization was founded more than years ago.

The company has more than employees.

Figure E.1: The first programmed prototype allowing users to search.

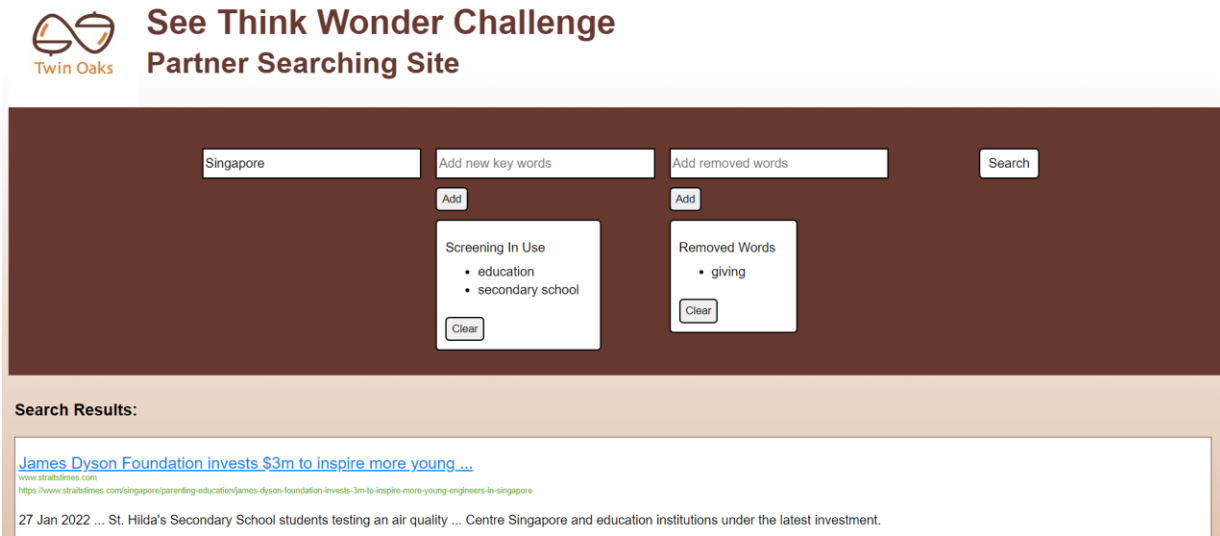


Figure E.2: The finalized high-fidelity searching tool.

To help Twin Oaks employees use the partner searching tool, our team created a user manual. This user manual relies on pictures to tell processes and stories with minimal text. In total there are three general sections: ‘What is this tool for’, ‘How to use the tool’, and ‘How to optimize search results’.

The last deliverable was a live demonstration for the employees of Twin Oaks. We demonstrated to the Twin Oaks employees how to utilize our search tool; we explained how to input keywords, navigate the website, and optimize search results. This demonstration was supplementary to the content in the user guidebook.

The project had some limitations during its development. Time constraints were serious as the development had a seven-week time limit, further constrained by a scope change towards an API. User testing, an important part of the software engineering process, was limited due to the virtual environment and an inability to conduct a user feedback survey on Twin Oaks employees at the sponsor’s request. The software itself also imposed restrictions on our project’s development.

Instead of developing a self-made search engine, we utilized Google's Custom Search API to provide effective results. This custom search API allowed for easier filtering of search results and querying through relatively simpler code compared to a self-made search engine. To get the best results, we implemented filters in the API's configuration and fields for user inputted keywords to further narrow results. Initially, the API's location feature was not creating functional results. To overcome this limitation, the team developed a workaround that allows the user to input the location, which generates better location-based results.

We found that designing a user interface around convention and establishing a sense of familiarity with users by mirroring other searching sites and Twin Oaks's own website made the website easier to navigate. To validate efficacy, during the final demonstration of the tool, all employees at Twin Oaks had no questions and had developed an intuitive understanding of how to use the site. The immediate understanding and lack of questions means that the user interface accomplished its goal of simplicity. Additionally, the recording of our training session was saved by Twin Oaks to further serve as a reference for the tool's usage.

The user manual was developed using other common manuals as reference. This methodology proved effective as Twin Oaks employees were satisfied with the final manual and had no questions. The manual was saved for later use due to its efficacy to help train other employees.

By iterative development reliant on consistent feedback and improvements, we were able to develop a complete and functional tool. Additionally, our tool's implementation of Google's Custom Search API in a novel search space proves the efficacy of the API for similar searches. This tool will be a catalyst in Twin Oaks's educational reform mission by connecting them with organizations to ultimately reach students who need help developing new, modern skills.

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1.0 Introduction

Critical thinking is a necessity for companies in the 21st century (ManpowerGroup, 2018). Despite academic success, there are shortages in the East Asian Education Model, especially with leaving students with underdeveloped critical thinking skills. Several nonprofit organizations, such as our sponsor Twin Oaks, have attempted to fill this void. However, communication and networking between these organizations is difficult. Twin Oaks needs a means to contact local organizations in several different countries, specifically Singapore and Hong Kong, to spread their *See Think Wonder* Challenge that facilitates critical thinking. This team was tasked by Twin Oaks to create a searching tool to find these partner organizations to further spread this Challenge.

East Asian education systems are designed to teach students through assessments and examinations. According to the Hong Kong Curriculum Development Council (CDC), the Hong Kong Examinations Assessment Authority (HKEAA), and the Education Bureau (EDB), “(examinations) had aggravated the washback effect ... on student learning. In other words, it had accelerated competition for the highest grades in an already highly competitive environment.” (James, Mary, 2017). The curriculum mainly focuses on student performance on assessments, resulting in unintended consequences like the washback effect. The washback effect is the influence testing has on the way students are taught. For example, teachers are teaching students to take the test well because they want their students to be competitive. Consequently, the assessment-oriented curriculum places little emphasis on critical thinking.

Twin Oaks is a start-up, non-profit organization that is interested in spreading the development of critical thinking around the globe. They aim to ensure all younger generations have the most effective education that enables them to supplement the critical thinking skills that

are not taught in schools. To achieve this, Twin Oaks started the online *See Think Wonder* Challenge in 2021 as a pilot program to stimulate critical thinking amongst Taiwanese students. However, given that Twin Oaks's reach is small, they do not have the necessary resources to grow into new regional markets. Twin Oaks needs to find regional partners that are willing to spread this educational reform challenge. These regional partners can be found using a user-friendly tool developed for Twin Oaks employees to limit search results from Google.

Specifically, we are looking to develop a partner searching tool for Twin Oaks to find organizations in Singapore and Hong Kong that might be willing to collaborate with Twin Oaks's mission of spreading the development of critical thinking through the Challenge. It is important to consider the technical, human, and cultural aspects of how to make an effective tool for Twin Oaks to find suitable global partners. Our goal was to develop an accurate and user-friendly partner searching tool that allows Twin Oaks to find suitable partners to expand their *See Think Wonder* challenge, as well as help both their current and future employees understand how to use the tool effectively.

Our team identified two main objectives for the partner searching tool:

1. Design a program that can find partners with the correct characteristics.
2. Implement an interface that allows the program to be used by staff members of Twin Oaks, regardless of computer skill level.

The team first generated a set of search criteria which potential partners had in common. These search criteria form a query for a programmable search engine through Google's Custom Search API, which was utilized throughout the project to search for fitting partners for Twin Oaks. Through iterative development of prototypes, the team established a user interface that allows users to interact with this API in the easiest manner. To complement this interface, a user

guide was designed to allow any user to learn every feature about this searching tool. To finalize the development of this tool, a live training session with the employees of Twin Oaks was a presentation of the finished tool to outline its use and results.

2.0 Background

To help develop a comprehensive tool for Twin Oaks, we first had to understand the cultural aspects of East Asia that have led to a lack of critical thinking promotion in East Asian education systems. To help Twin Oaks solve this problem, we needed to develop a tool to help them find partners to spread their message. To find the partners, we had to research common practices for data searching. Additionally, for Twin Oaks to fully interface with the search data, we had to research common practices for UI design.

2.1 East Asian Education Model

East Asian countries perform well on education assessments like PISA and have been known for producing high-performing students. The highest performing nations such as Japan, China, South Korea, and Taiwan contain similar models and education structures, which follow the East Asian Education Model (EAEM). The EAEM model is backed by East Asian cultural roots of Confucianism. The main idea of Confucianism in terms of human performance comes from “Li” and “Dao” meaning harmony and excellence. Confucianism emphasizes harmony on all levels meaning nature, community, family, and state (Zhu, Gang 2021). East Asia connects their culture of harmony and excellence through the structure of its education system having a disciplined and high-pressure environment. Education harmonization is a term that comes from Confucianism, that “brings together different and contradictory means and ends to achieve desired educational outcomes” (Chen, 2019). This can be seen in the education system from their school curriculum, class environment, and learning for assessment approach.

The curriculum in Asian countries is disciplined and strict. The classroom structure exhibits this due to the “Teacher-Directed Student-Engaged” pedagogy (Tan, 2019). Teachers are in control over the curriculum and authority as well as encourage students to be engaged.

This allows students to know what expectations they need to meet in the classroom. In turn, students need to rely on active learning to be engaged with the curriculum (Tan, 2015).

Specifically, the EAEM uses a “T-shaped” curriculum, where the horizontal line indicates the “breadth of the curriculum” and the vertical line indicates the depth of the curriculum. This system allows students to learn a broad range of subjects while honing depth and mastery of skills (Tan 2019). The strength of this type of curriculum is that students develop well-rounded skills in various subjects. The drawback of this curriculum is the high-pressure environment it puts on students. The education system employs this knowledge building and the high-pressure environment by emphasizing assessment for learning (Conley et al, 2017).

Assessment for learning (AFL) is the strategy of testing individuals' knowledge through formative assessments. AFL practice grew after the 1990s in the Asia-Pacific region (Klenowski, 2009; Birenbaum et al, 2015). This method focuses on frequent assessments to show students' understanding and progress with the material. In Hong Kong, assessment is viewed as an integral part of the learning and teaching cycle and systemic measures were introduced to ensure that assessment is valuable to learners (Leong, Wei Shin, et al 2018). The strength of the system is that it shows where students progress and the effectiveness of teaching methods. Even though assessments can aid in progress development, it emphasizes cramming and studying. The constant streamlining of information and repetition in this environment is a method called rote memorization. The main problem with these exams is promoting superficial learning using rote memorization to store more information rather than depth of information (Johanns, 2017; Klenowski, 2009).

According to many experts, rote learning is necessary to a certain extent because it is useful for specific applications. For example, memorization helps build foundations for learning

more complex concepts (Ishartono, 2016). For Hong Kong and Singaporean students, the learning process emphasizes repeating verbatim what is taught rather than analyzing the material. Rote memorization is encouraged simply because it is used as a traditional teaching method (Li, 2004). These methods focus on the memorization of facts rather than of the concepts (Snyder 2008). This happens especially with students that focus on assessments (Johanns 2017). The main disadvantage of rote learning is that it does not provide a full understanding of facts and their relationships with one another (Ishartono, 2016). The modern economy, which can be described as knowledge-based, requires people who are critical, creative, and adaptive (Poon, et al, 2008). The skills developed by rote learning create high-performing students on assessments but can limit students' quality of learning, thinking, and conceptualization thus limiting their ability to contribute to the current knowledge-based economy.

The main problem within the East Asian education system is the curriculum and classroom environment. Even with a T-shaped curriculum and assessments to show student growth and learning, the high-pressure environment gears student focus into memorization rather than comprehension. The EAEM model produces high-performing students, but the environment and focus of assessments and rote memorization can limit students' depth of learning rather than enhance it.

2.2 See Think Wonder Challenge

Twin Oaks' Founder Maggie Lin created the online *See Think Wonder* Challenge in 2021 as a program to help develop critical thinking skills in high school students. This program takes inspiration from the Harvard Thinking Routines. A thinking routine is a set of questions used to support and gauge critical thinking. Specifically, the *See Think Wonder* thinking routine consists of three questions: “What do you see?”, “What do you think about that?”, and “What does it

make you wonder?” (Twin Oaks, 2022). The purpose is to encourage students to make careful observations and interpretations. These routines help aid people's way of thinking and go beyond surface-level analysis (Gardner et al., 2000).

The challenge consists of three steps completed over the course of 3 months:

1. *Make Observations.* Students make observations and comparisons between similar objects as a first step to identifying details about successful products or businesses.
2. *Extract Meaning from Those Observations.* Students think and ask questions about why particular details of a product or business are significant to its success.
3. *Apply Best Practices to Real-World Problems.* Students apply the critical thinking skills they developed to real-world environments.



Figure 2.1: Comparison of an outdated and a modern Coca-Cola vending machine.

The ‘Make Observations’ step is where students take an old and new vending machine, for example, and focus on their key differences such as the modern vending machine having a see-through glass panel to allow consumers to see the available drinks.



Figure 2.2: Observation of the K-City Market in Finland, labeled the best grocery store on Earth.

The grocery store in Figure 4 might be presented to students during the ‘Extract Meaning from Those Observations’ step. Students observe and think about what aspects of the K-City Market make it so successful and revered such as the professionalism and atmosphere.



Figure 2.3: Real-world observation of a supermarket in Taipei, Taiwan.

In the ‘Apply Best Practices to Real-World Problems’ step, students visit the Taipei grocery store, seen in Figure 5, and apply best practices to improve the store’s quality. For instance, students may observe the lack of professionalism in the grocery store and may suggest solutions to improve the layout and product organization.

Mrs. Lin structured the *See Think Wonder* challenge to allow students to assume real-world occupations to contribute to the play-based learning principle of this challenge. For instance, the challenge depicts the student assuming the role of a designer during a store visit and proposing improvements (Twin Oaks, 2022).

2.3 User Interface Design

When looking at any object, humans make an instant, unconscious scan of an object and determine conclusions based on this initial scan. Even once the conscious mind takes over, people unconsciously influence their conscious decision with this first scan. Designers work with this quality of human thinking to create interfaces, a method for users to interact with a program,

that create the best first impression. Interfaces require simplicity, clarity, and good aesthetics to allow users to fully like and understand the interfaces almost instantly (Fessenden, 2017).

Implementing a bad user interface makes potential users either confused or renders the tool unhelpful. Both improper and lack of use of an interface result in users not utilizing the associated program's services efficiently. Oftentimes, this means monetary loss; on the massive scale of the internet, this loss could become massive (Nielsen, 2008).

A user interface should be intuitive and guide the user toward the solution they seek. Thus, interface design can only properly be done after a research question is established (Norman, 2002). However, a vague problem can lead to a vague, complex, and ultimately confusing user interface. Due to this, having a refined question and problem also allows the focus of solutions to be refined due to a more focused user interface (Kelley, Littman, 2001).

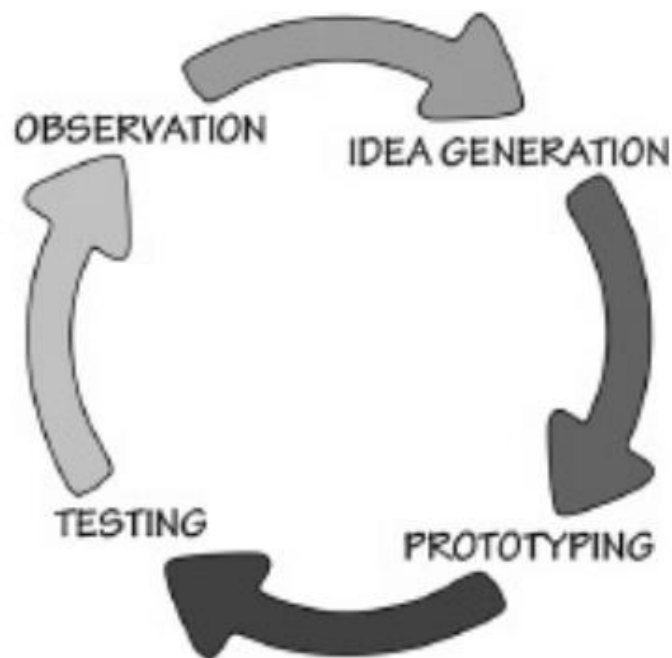


Figure 2.4: The cycle of iteration in user interface design (Norman, 2002).

Iterations and consistent feedback are the cornerstones of the interface development process. It is critical to recognize that user interfaces do not generate the best user experience at the start of their development. As seen in Figure 6, iterations are driven by a cycle of making observations and forming ideas to implement in an iteration of a prototype, which is then used in a qualitative testing environment to gather more observations. This loop repeats until the users determine the interface to be suitable for their use (Norman, 2002).

It is common practice in interface development to start with an unprogrammed user interface that simulates the flow of an actual interface with predetermined, or ‘canned’ responses. Low-fidelity prototypes are minimalist and contain undeveloped aesthetics that are evaluated and tested for their user experience before aesthetically pleasing versions are made.

Developing a programmed version of the prototype is the next step in development. This process removes the ‘canned’ responses and provides a more interactable version of the low-fidelity prototype. Due to increased intractability, users can provide more accurate feedback as the prototype more resembles the final product (Woolley et al, 2013). Iterative improvements are then made to these prototypes, and once there is consensus on the best design of an interface a high-fidelity prototype can be developed.

High-fidelity prototypes add aesthetics such as color schemes and font designs that are pleasing and add to the flow of the interface, and this prototype will turn into the full interface through continuous improvements (Rettig, 1994). These choices not only add a ‘beautiful’ factor to the interface, but the color scheme and artistic style direct the user’s attention and contribute to the flow of the high-fidelity prototype. Color hierarchies allow websites to focus the attention of users on various features, and a consistent style allows ideas to be conveyed easier (Gibbons, Gordon, 2021).

User interfaces are usually programmed in the native language of the device being used. Since this project is about developing a website, we can utilize the programming language of JavaScript, the markup language of Hypertext Markup Language (HTML), and the sheet style language of Cascading Style Sheets (CSS). The structure, or the skeleton, of the interface, is written in HTML. This includes adding the text, input boxes, and buttons of the web page. To add functionality to the interface, we can utilize JavaScript to add functions and logic that allow the interface to flow. Some JavaScript functionalities include interactions with a list of values, reading information that can be used in a search query, and interacting with a third-party service like an API. For adding aesthetic changes to prototype websites, CSS is used to change and add stylistic changes to our interface (Miller, 2022).

2.4 Use of Application Programming Interfaces

Application Programming Interfaces (APIs) are an integral part of linking computer programs to other, more expansive, services. Programmers use APIs to access data or information that is not typically accessible to the average user (Bloch, 2006). One expansive use case for an API is to access a common set of databases of specific material. This eliminates the need for each application to program a searching algorithm to scan the web for a desired piece on the web. For example, an API can be a tool developed by a community of researchers that can allow users to search for, input, and modify data on cross-bred plants in a central database. This API that accesses data on plants was developed with the goal to standardize the use of communicating research data with the numerous custom applications used by researchers around the world (Selby et al., 2019). In another case, a materials science database (which was programmed and populated with data before the development of the API) required an API for users to access tens of thousands of complex crystal structures and their properties for analysis

by the user. This directs human effort and computational power away from searching for and parsing materials data from the internet to focus on more disciplinary computational analysis, improving efficiency and accuracy (Ong et al., 2015).

These two APIs connect to their respective databases using a searching format called Representational State Transfer (REST), this allows the API to receive input parameters as a Uniform Resource Locator (URL). In the case of searching for a particular piece of data. The user programs the inputs, which is very dependent on the program; with the inputs obtained, the API accesses the database and transfers data utilizing Hypertext Transfer Protocol (HTTP), a conventional format that many programs use to transfer data, especially on the web. Once the data in the database has been found and compiled, the API sends the information back to the user program for displaying or for performing additional calculations (Ong et al., 2015; Lahey, 2016; Selby et al., 2019).

When it comes to searching the internet for niche websites, Google's Custom Search API can be utilized to create custom Google searches as well as refine and impose filters on the website results (Google, 2020). This Custom Search API is analogous to searching in a Google Search Bar, but with additional functionalities and filters. These features include searching from the entire web to a single web page. It can also show only results that include specific words, ban results that contain other words, search within a specific domain, as well as prioritize, restrict to, or prohibit certain file types (Schmick et al., 2012).

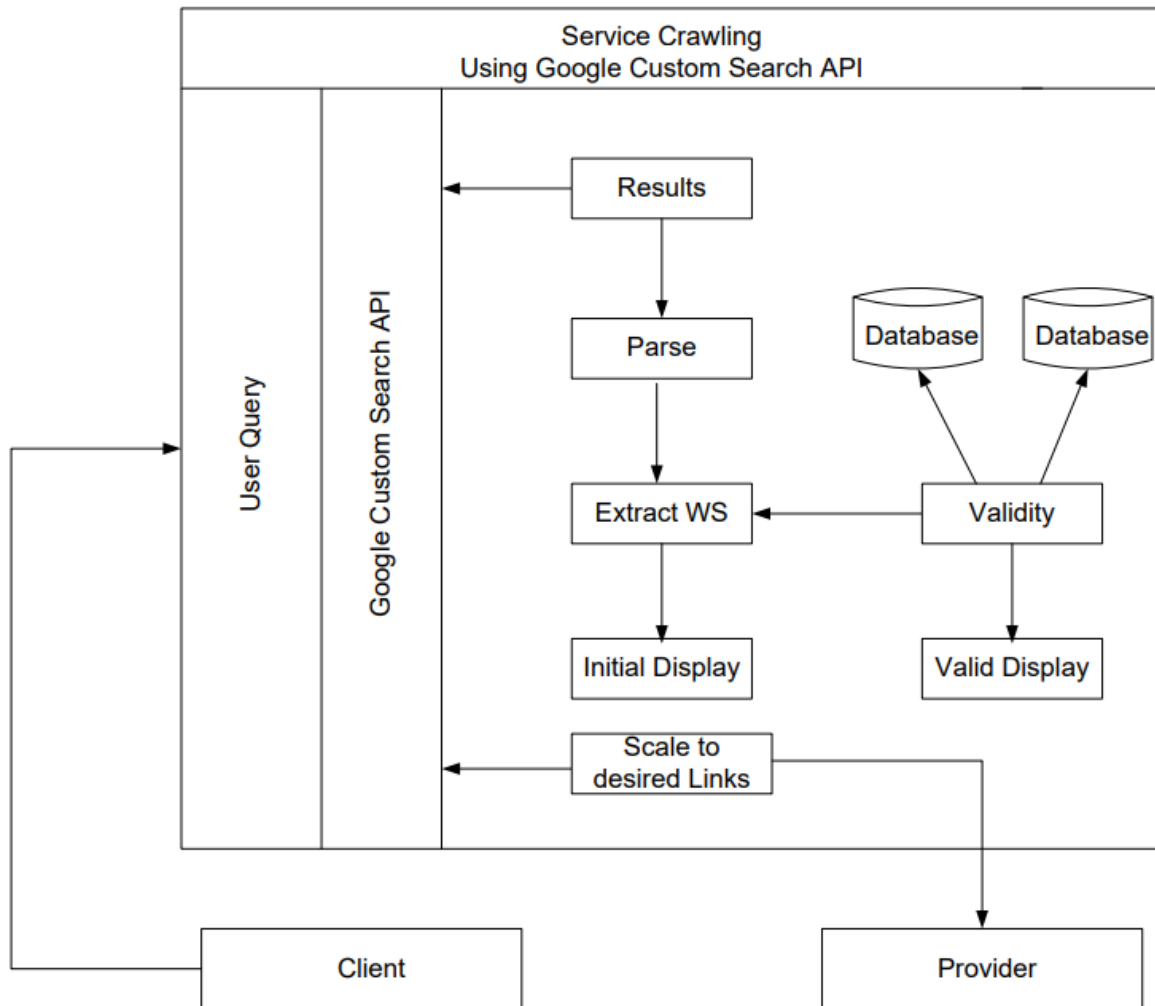


Figure 2.5: A use case of Google's Custom Search API (Allauddin and Azam, 2011).

Google's Custom Search API also operates under the REST format of searching, where a URL developed by a user program is the input that contains the search. A simplified example url might look like this:

https://customsearch.googleapis.com/customsearch/v1?key=*****&cx=*****&q=Learning+Singapore+-+donation&cr=countrySG&gl=SG.

The variables in this search are as follows: key, cx, q, cr, gl, exactTerms, orTerms start, hq, excludeTerms, and callback. Key and cx are used to access the API and programmable search engine. They are blocked out as it is unsafe to publish these numbers since the usage of

the API is linked to Twin Oaks's credit card. These variables remain static as every search should always use our API key and Programmable Search Engine. The variable *q* contains the query. Since *q* is set to 'Learning+Singapore+-donation' this means that the query sent to the API will be 'Learning Singapore -donation'. The '-donation' ensures that all results do not contain the word 'donation'. The location specific variables are next: *cr* and *gl* are set to countrySG and SG respectively. This specifies only Singapore results to be shown. There are many more variables, all of which are tweaked exactly as the ones stated here.

Utilizing the Google Custom Search API has increased the "chances of [finding results] which are updated and exact" (Allauddin and Azam, 2011). It must be kept in mind that all of these cases are use-specific, and do not necessarily translate to every project. Therefore, each API implementation is highly case-specific and typically unique (Asyrofi et al, 2020). However, it should be stated that well-crafted APIs should not require complex programming skills (Schmick et al., 2012). This means that APIs should be easy to pick up and incorporate into new projects, including the Google Custom Search API.

2.5 Conclusion

The background outlined the faults of the East Asian Education Model, the sponsor's mission of the *See Think Wonder* Challenge, and practices behind both Application Programming Interface and User Interface Development. As the 21st century economy evolves, it requires a workforce that is well versed in critical thinking methods and is able to solve complex problems. However, the EAEM's basis on rote memorization and assessment-based learning underdeveloped this skill in its students, resulting in an underprepared populace for the modern work environment. To counteract this underdeveloped skill, Twin Oaks developed a

play-based learning challenge based on Harvard's Critical Thinking Routine to allow students to develop critical thinking. To spread this challenge, a program can interact with Google's API to use Google's custom searching service. Developing a user interface to allow users to interact with this API requires iterative development. This involves a cycle of consistent feedback from users testing a prototype; feedback from this allows developers to create a new and improved prototype. This cycle ends in a high-quality finished product.

3.0 Methods

The goal of this project was to develop a searching tool to connect employees at Twin Oaks with global partners who can assist them with the expansion of the *See Think Wonder* Challenge to Singapore, Hong Kong, and beyond. The team accomplished this goal through two objectives:

1. Design a program that can find partners with the correct characteristics.
2. Implement an interface that allows the program to be used by staff members of Twin Oaks, regardless of computer skill level.

Initially, Mrs. Lin wanted us to cross-reference results from our tool with Google. However, we eventually agreed upon using Google's Programmable Search Engine in tandem with the Google Custom Search API. We arrived at this decision since if we were going to cross-reference with Google, then Google must have the information we wanted. It was more time efficient to build off of what Google had developed than to try to build a search engine from the ground up. The Custom Search API works in tandem with the Programmable Search Engine enabling us to create a filtered search engine, which allows for tailored results focused on education non-profits.

The Custom Search API allows our website to remotely use our Programmable Search Engine and search with different terms to yield different results. Our team conducted archival research on sources that implement interface design and a searching API. Additionally, our team utilized several online resources to resolve technical issues during the development process. Upon completion of the prototype, we developed a user guidebook and conducted an online training conference using Zoom to teach Twin Oaks employees how to use the website in the last week of development.

A full timeline of the project's development can be seen in Table 1 in the Conclusions section.

3.1 Selection of Criteria and Keywords

Before searching for partners, we generated a list of good partner characteristics based on the objectives and vision of Twin Oaks. This list ensures that the search has a sufficient query to target specific organizations and prevents searches from being too broad, but also encourages contextually relevant results. We determined these characteristics through an iterative process beginning in week 1. We were directed to look at HunderED by our sponsor due to their high credibility and network of organizations. We scraped the top 100 organizations of 2019 and 2020 from HunderED, an organization that awards the top 100 education companies every year (HunderED, 2022). To accomplish this, we created a Python script that made HTTP requests to the HunderED website using the Beautiful Soup library. The Beautiful Soup library is a common library used to grab text and other elements from websites using HTTP requests. HTTP requests are used every day to access pages. For example, when you want to go to <https://google.com>, your computer makes an HTTP request to <https://google.com> and then displays the information. The only difference with Beautiful Soup is that instead of displaying the information as a web page, it stores the data of the webpage. We can then parse out the relevant information, in our case the text of the webpage. We found the location of another link on the page to the organization's website and stored that link. We then scraped the text from each of these organizations' websites simply by repeating this process with the new links. We concatenated all the text together and found the most frequent words then developed a word cloud (Figure 8) to help visualize the potential search space (Richardson, 2015). The larger the words the more

frequent the words were on the web pages.

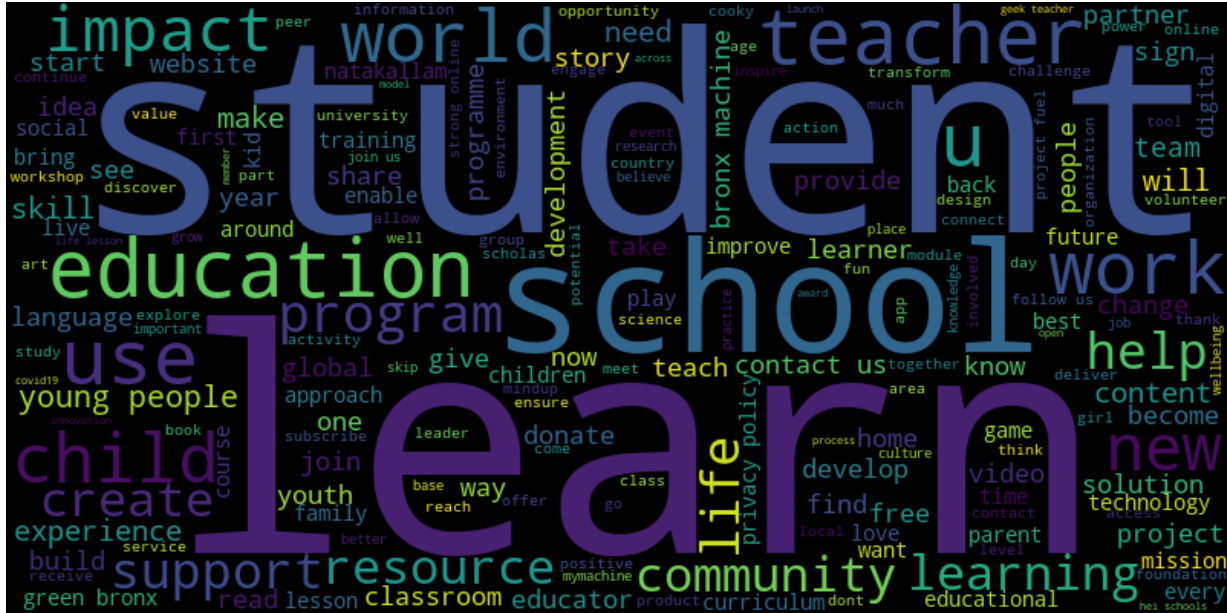


Figure 3.1: Word Cloud from HundrED's organizations.

After several iterations, these words eventually became our first set, or first layer, of keywords used to narrow the Programmable Search Engine. Our sponsor provided feedback and helped select which frequent words were important to narrow the search further. At the discretion of Mrs. Lin, our team chose the top 30 most frequent words, then further filtered them down to only five: learn, school, student, teacher, and education. We filtered them by entering different combinations and seeing which words yielded the best results. This work was essential to developing an effective searching tool as an organization that uses these keywords on their web page would identify them as a potential partner to market the *See Think Wonder* Challenge. It is important to note that the keywords did not contain the location/country where the search was supposed to take place, a task we accomplished later.

In addition to the list of keywords, our group also performed a holistic, qualitative analysis of the HundrED organizations. This analysis yielded several characteristics that these

organizations held in common. Some qualities included being a registered nonprofit, focusing on marginalized groups, and inspiring critical thinking. We sent this list of criteria to Mrs. Lin along with our keywords. Keywords became the words and phrases we used to identify an organization as a potential partner and search criteria became the characteristics that filter out unsuitable or irrelevant partners.

3.2 Back End Program Development

Since Twin Oaks needed refined searches, we determined that using Google's Custom Search API would be best. We came to this conclusion because the Google Custom Search API enabled us to search using Google, varying our queries and engine parameters to tune our results. The API allows users to enter specific keywords to tailor searches. Additionally, the API can filter by several Schema.org schema; a schema contains labels for websites and allows for more specific searching (Google, 2022). However, we found that this filtering was too restrictive and ultimately unhelpful.

The API is not the only component of the back end of our program. The API is not useful on its own as Twin Oaks employees cannot interact with it directly. To tackle this, a JavaScript application was implemented to communicate with the API. This JavaScript application makes an HTTP GET request to the API's URL with a specified query attached to the end of the URL, as is standard in REST APIs. The API then returns the top 10 results. These results contain the hyperlinks of each page and the descriptive text of each page. However, since JavaScript is not user-friendly because it lacks an interface, the results were displayed on a subsequent HTML page. The team used JavaScript and HTML to develop the user interface and create a functional website that enables Twin Oaks to search for sponsors using Google's Custom Search API.

The initial task was a data crawling algorithm to find regional education nonprofit organizations. Instead, our team found that developing a searching tool to use pre-existing search engines, like Google, was a better method of finding these organizations. This was in part due to the limitations of time, but also because pre-developed search engines like Google provided significantly better results than what we would have been able to program due to the hundreds of billions of web pages already in Google's database (Google, 2022).

Despite building on top of pre-existing engines, our team still found it difficult to properly narrow our searches for organizations. Our tool returns germane organizations; however, some organizations are missed because they are difficult to find. Our tool can only find an organization if they have a good internet presence.

Additionally, Google ranks results based on foot traffic; a site with more traffic will get recommended more (Safari Digital, 2022). The result, therefore, contained more websites that link to nonprofits than the nonprofits themselves. This foot traffic-based search led to somewhat bloated search results, and consequently, not every result was accurate. Although, it was unrealistic to assume it would; Google's search engine returns results that are often unrelated.

Despite these limitations, we found that the Google Custom API, Google Programmable Search Engine, and countless iterations resulted in a product that could find several partner nonprofit organizations for Twin Oaks.

3.3 Interface Development

In conjunction with the back-end development, the user interface was developed with the intent to allow employees of Twin Oaks who have no knowledge of the API or programming, in general, to utilize this searching tool easily and efficiently. Three of our four team members studied prototype design in Human-Computer Interaction. This course introduces the

implementation of low and high-fidelity prototypes using PowerPoint, HTML, JavaScript, and CSS, including the necessity of user testing and iterative development. Using what we had learned from this course, we decided to start with a low-fidelity prototype. Before our team could design any version of a user interface, we had to identify what Twin Oaks needed in a searching tool. To determine which features Twin Oaks needed in the user interface, we discussed ideas with our sponsor. These features include an input for custom search words, as well as a button to include pre-determined words to refine results. We also included a function to filter for characteristics with an inequality. For example, allowing the user to only search for organizations more than 3 years old. This was initially an important feature that Twin Oaks wanted. The user should also be able to see a set of outputs of a user-determined size, each result should contain a title of the organization with a URL to be displayed as roundrects (a rectangle with rounded corners), easily distinguishing each organization for users. With these functions in mind, our first low-fidelity prototype was prepared in Google Slides, as seen in Figures 9 and 10, to demonstrate the functions of our user interface quickly and efficiently to the sponsor. We chose Google Slides because slideshows are easy to make, share, and present to the sponsor for feedback. However, this prototype did not include any programming, and thus, the interface's features did not have any functionality.

Twin Oaks Education

The Data Crawler

Add Recommended Keywords

Or add your own:

Add Text Here

Keywords:

Add

Add Criteria:

Select a Criteria ▼

Add Inequality ▼

Number

Criteria:

Add

Search for Top Results

SEARCH

Figure 3.2: The unprogrammed low-fidelity prototype made with Google Slides.

Twin Oaks Education

Search Results

Organization 1
https://example-website.org

Organization 2
https://example-website-2.org

Organization 3
https://example-website-3.org

Organization 4
https://example-website-4.org

Organization 5
https://example-website-5.org

Organization 6

Figure 3.3: The second page of the unprogrammed low-fidelity prototype.

Since we were working with the API in tandem with the interface, the team decided to program functionality into the next iterations of the low fidelity prototype using JavaScript, the native language for websites. We programmed in the Visual Studio Code Integrated Development Environment (IDE) because it was well integrated with the GitHub application, as well as being convenient to use. IDEs are like text editors for coders; it does not matter which one you use and is ultimately up to personal preference. IDEs provide several developer tools (error detection, autofill features, etc.) that make programming simpler, making its use common practice among developers (Microsoft, 2021). Additionally, GitHub, a popular collaborative coding service, is an industry-standard for collaboration among multiple developers that allows multiple programmers to work on one project without the arduous task of switching and overwriting files manually (GitHub, 2022). As for the structure of the page, we used the markup language HTML, creating the heading of the page, the layout, the text box, and the buttons as well as linking the inputs and resulting web pages. While this was the foundation of the website, this low-fidelity prototype lacked aesthetics.

The demonstration of the first low fidelity prototype in a meeting with our sponsor allowed them to give feedback, this feedback continued through successive iterations demonstrated by email as the sponsor and their employees are the users of the interface (Farrell, 2017). The first programmed low-fidelity prototype changed the button to add pre-determined or 'recommended' words into a checklist to allow for more customizable searching while maintaining time efficiency for users. This prototype also removed the inequality characteristics as they were found to be inconvenient to use, worked poorly with the querying by the API, and were found to be unnecessary for searching as Twin Oaks was no longer focused on these qualities of companies. In addition, a later improvement allowed the results to be displayed on

the same web page as the inputs; having both inputs and outputs on the same web page allows users to change search queries as quickly and easily as possible, improving the number and quality of compatible results. These improvements can be seen as the final low-fidelity prototype, shown in Figure 11.

Twin Oaks | See Think Wonder Challenge | Partner Searching Site

Country / Region:

Basic Screening:

- Project-based learning
- Creativity
- Collaboration
- Problem-solving
- Scientific thinking
- Critical thinking
- Design
- Innovation
- Real World Learning
- Leadership
- Life-long learning
- Soft skills
- 21st century skills

New Screening:

Screening In Use

- Outreach

Search for top results.

Potential Partners:

- ARNOVA's Catalog of Current Research
https://www.arnova.org/resource/resmgr/catalog_of_research/2018_catalog_of_research.pdf
- Leadership In Faith-Based Nonprofits As Compared To A ...
<https://core.ac.uk/download/pdf/58822514.pdf>
- Nonprofit - Page 3 of 5 - The Borgen Project
<https://borgenproject.org/tag/nonprofit/page/3/>
- Provisional list of NGOs, non-profit making institutions and experts

Figure 3.4: The final low-fidelity prototype.

After developing a sufficiently programmed low fidelity prototype with structure and features refined, a high-fidelity prototype allowed the team to add aesthetic designs and stylistic choices. The stylistic choices of a high-fidelity prototype help guide users through clarity and hierarchies of functions in the interface. (Gibbons, Gordon, 2021). Since the low-fidelity prototype was programmed beforehand, the high-fidelity prototype utilized the code from the low-fidelity prototype to develop a functional model of the website. The high-fidelity prototype incorporated the color scheme of Twin Oaks, as it was the most familiar and involved both dark and light tones. These tones established a duality between the inputs section and the results section, focusing the attention of users on what to do first. We also changed the inputs' layout to be read from left-to-right so that the users must read through the input boxes before the search button. To ensure that the inputs were recognized first by users, the sponsor recommended the

inputs be on the top of the outputs section instead of next to each other. This prevents searching before the user has completed their query.

Multiple functionalities were programmed in iterations of the high-fidelity prototype. The first prototype included multiple pages, allowing users to see 10 new responses without the need to input new parameters into the search query. To remove typos in the location field which caused the input to not be recognized as an accurate location by the program's location-specific feature, a drop-down menu was installed to help users input the correct location's name. To allow for more specifications in the search, the inputs section contains an input for users to ensure words irrelevant to the search were banned. The phrase 'financial aid' is one example that might be undesirable for Twin Oaks's searches. Another feature saves selected results to a CSV file, allowing users to easily export desired partners to other people. The results in the final interface not only display the title of the organization's web page, but a small amount of text describing the organization, a short URL to discern the domain of the website, and a long URL to detect suspicious links. These results are in close rectangles that closely resemble Google's conventional results, providing familiarity to users.

After all of the features were included as new iterations and the website was decluttered to increase the clarity of the interface, the final user interface was ready to be incorporated in the user guide and demonstrated in live sessions. The final interface is shown in Figure 12.

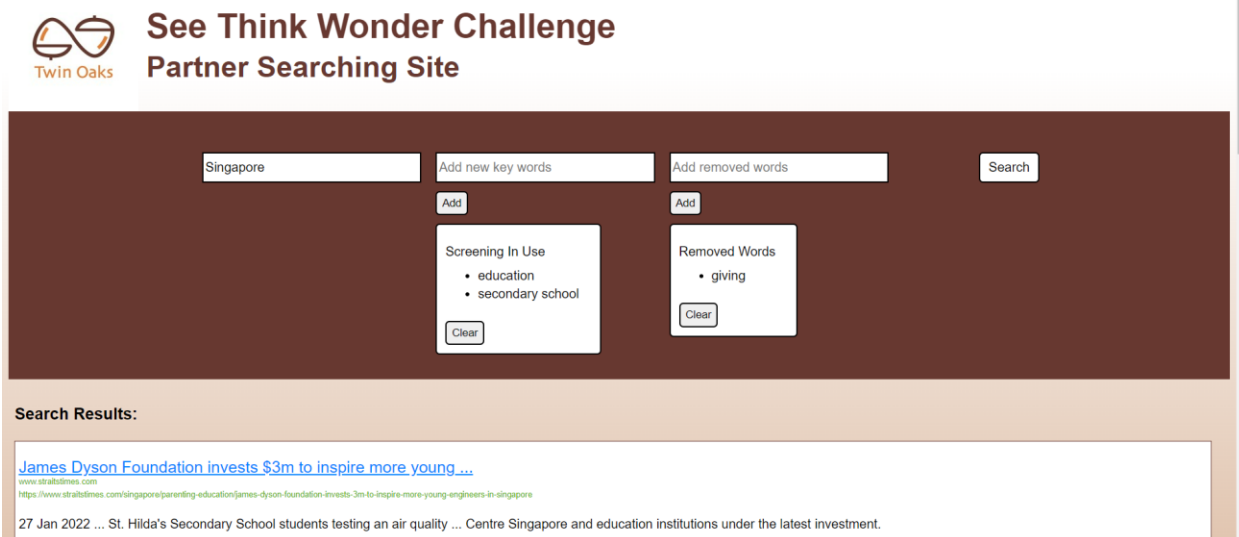


Figure 3.5: The final design of the user interface.

The team designed eight iterations over the five-week period of developing the interface, which yielded a significant number of changes from the first prototype to the final interface. The final interface includes numerous features to streamline the experience of the users and allow users to learn the functions of the searching tool as quickly as possible.

3.4 Developing a User Manual

To help Twin Oaks employees use the partner searching tool, our team created a user manual. We needed to identify what aspects of our tool should be documented within the manual, where Mrs. Lin stated three general sections: purpose, how to use, and workarounds. The next step was to create a table of contents for the user manual. Figure 13 shows the table of the contents of the user manual, where we outlined clear areas to be explained from the partner searching tool. Before the table of contents, there is a title page with the organization's logo. This was added for aesthetics and to add a sense of professionalism to the manual.

| | |
|---|----------|
| 1. What is this tool for? | 3 |
| 2. How to Use the Tool? | 3 |
| 2.1 General User | 4 |
| 2.1.1 Navigating the website | 4 |
| 2.1.2 Screening and Getting Results | 5 |
| 2.2 Engineer Use | 8 |
| 2.2.1 Use the API | 8 |
| 2.2.2 Important Features | 8 |
| 3. How to workaround filtering search results? | 8 |
| 3.1 Location and non-English Setting | |
| 4. Appendix | 9 |
| 4.1 Definition of Screening layers | 9 |

Figure 3.6: Table of Contents of User Manual

After drafting the outline of the user manual, we decided to look at existing examples of user manuals. When looking for examples, our team focused on finding user manuals for web applications since our partner searching tool is through a website. We used Google Scholar to find established user manuals. Google search engines gave results that were tips on how to create a user manual in general, but Google Scholar gave more specific examples of actual published user manuals. It was better to have examples to look at when creating the user manual. One user manual found from Google Scholar was the “La Plata” user guide. La Plata is a user guide from a WPI IQP project, where they explain to users how to use a SquareSpace account to fix and change a website (Rodriguez, 2021). This was a useful example of a user guide for us since they were guiding users on how to use features on a website to get results to update a page. The La Plata user guide shows heavy reliance on images to guide users on features and a step-by-step

process on how to update a website (Figure 14). In addition, our sponsor directed us towards IKEA manuals. Specifically, IKEA manuals are easy to follow as it also shows emphasis on images and goes through a step-by-step process. From these we can see some common practices that are used in developing user manuals.

1.2 My Dashboard

This is the first page you will see after logging in. The three dots on the right of the page open a menu which allows you to change account settings and billing. When you first enter this account you will want to set up billing such that you can maintain ownership of the website.

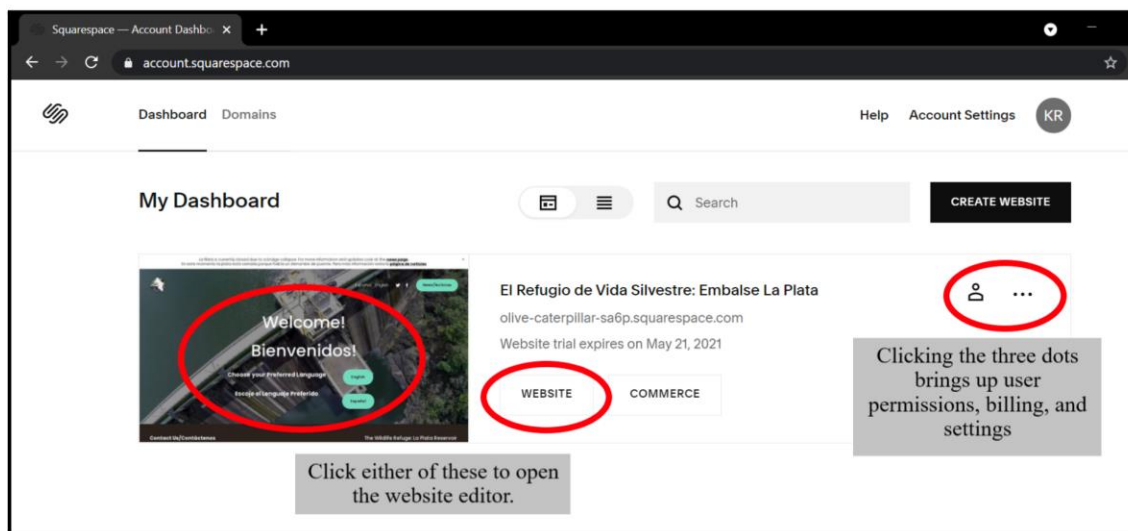


Figure 3.7: La Plata User Guide

Another way to find these best practices was searching for effective ways to write manuals and guide readers on a process. Pictorial communication is similar to verbal communication, where it can show an individual content that allows readers to visualize rather than just comprehend words. Of course, a picture can be misunderstood, so some minimal explanation would help guide readers in the right direction (Frixione et al, 2014). Guiding a reader through a process is easier when there are steps. A step-by-step process is easy to follow and should be in the correct order to guide the user. When explaining steps text shouldn't be too heavy and should explain the feature and function (Hodgson, 2019). When looking at the user

manual examples as well as best practices, the main conclusion our team drew was that guiding a reader is best through a step-by-step process (chronological order) with images. Pictures are easier for readers to visualize and follow on a website rather than reading the process and steps. Textual information should help explain pictures to readers but shouldn't overpower the images. After this research, the team moved onto developing the sections.

The next development was drafting out sections one and two explaining the purpose and how to use the tool. In this iteration, the team focused on images for users to follow a step-by-step process with minimal text from the conclusions we saw from our previous research. The "Screening Results" sections show a step-by-step process of using the region and adding keywords section with textual explanations of the images. The emphasis is shown in the images as they take up most of the page (Figure 15).

1. The region input screens what country or region is being searched into for results. Individuals can only put one country in at a time for a search. You can scroll through the list and click on the country or type in the country in the text box.

The image shows a user interface with two main sections: 'Basic Screening' and 'New Screening'. The 'Basic Screening' section on the left features a list of 14 skills, each with a checkbox. The skills are: Project-based learning (checked), Creativity, Collaboration, Problem-solving, Scientific thinking, Critical thinking (checked), Design, Innovation, Real World Learning, Leadership (checked), Life-long learning, Soft skills, and 21st century skills. The 'New Screening' section on the right has a text input field labeled 'Add new key words' and a button labeled 'Add'.

Figure 3: Shows the basic screening on the left side with chosen screening words checked in blue

2. The basic screening section has pre-selected words in a list. Individuals need to check off the specific word in order for it to be screened for the search. Based on what word is checked and how many words are checked can determine and change search results.

New Screening:

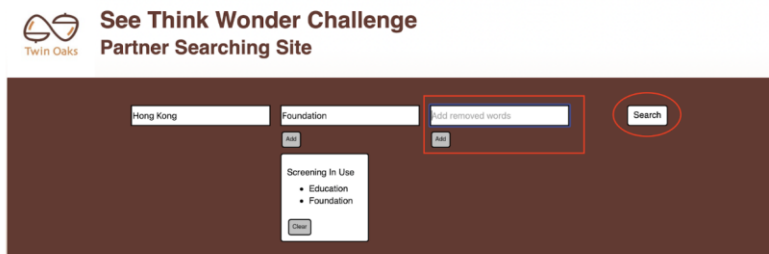
Figure 3.8: Screening Results Section (made in Week 5, the user interface was not finalized)

When submitting this section to our sponsor, the feedback was to condense the information and avoid repetition. The sponsor noted that since the UI was simple to navigate then the manual should be simple as well. The conclusion we made was to condense the subsections into one big section. Since the sections were too broken down and separated, we thought it was better to make an overall simple step by step process in the “How to Use the Tool” section. This ended up condensing the table of contents as well.

In the second iteration, the goal was to condense the textual information. The team took out repetitive information when explaining each step. Specifically, we saw that there were times

of over-explanation that were unnecessary. In the end we produced a polished and simple section on explaining how to get results (Figure 16). After finalizing the user interface and API features, we updated the manual pictures and explanations.

3. Add screening words to be excluded from the search (in the red box). Press the search button when the user is done inputting screening criteria.



4. Results will populate at the bottom. The blue text is the website link. The add spreadsheet button adds the website/organization into an excel sheet.

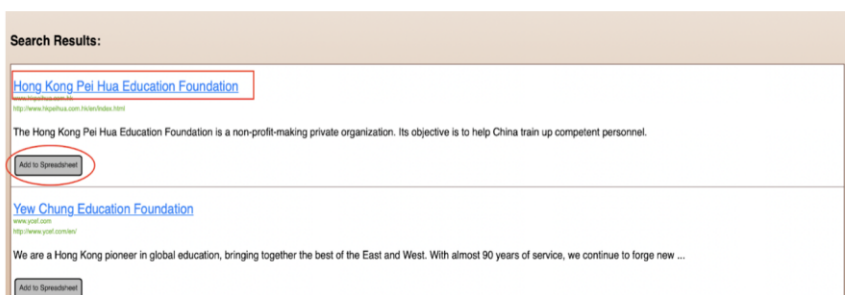


Figure 3.9: Updated Screening and Getting Results Section (Week 6).

The last development was writing the workarounds for the user interface. The team decided to do this last since our features and interface were finalized. Additionally, we can see what tips we can provide for Twin Oaks employees on optimizing the search results. In this section, we discuss what are examples of potential partners, candidates for other keywords, and solutions to potential problems that may occur. The team put in examples of potential partners as it gives a reference to employees on what kinds of organizations are potential partners (approved by sponsor). We added in other potential keywords for employees to use in this section because

our team tested keywords such as foundation, creativity, innovation, and design. We found that those words help yield better results and can help employees turn to these words to optimize their search results as well. Lastly, we added solutions to potential problems that could occur when using our website. For example, when using the Safari browser users are unable to save spreadsheets. Users would have to go to another browser such as Chrome or Edge to be able to use this feature. Adding a solutions section was important since it provides users ways to bypass the issue and for them to have better usage of the website. This last development led us to finalize the user manual with the necessary information such as process and solutions.

3.5 Live Demonstration

The last objective was to host a live demonstration for the employees of Twin Oaks. We demonstrated to Twin Oaks employees how to utilize our search tool: how to input keywords, navigate the website, and optimize search results. This demonstration was supplementary to the content in the user guidebook and lasted approximately 40 minutes.

As an initial step, we created an availability poll and determined that most of the Twin Oaks employees were available on April 26th, 2022, for a live demonstration hosted via Zoom. Nine Twin Oaks employees attended the demonstration.

During the training workshop, we initially demonstrated the functionality of the website. We focused our session on the aspects of the tool that were non-technical, while API settings that could be tweaked in the background were ignored. We demonstrated the ‘Location’ filter by selecting sample countries. Additionally, we demonstrated the ‘Add New Keywords’ and ‘Remove Keywords’ filters by selecting sample words that we required the search results to have and words that the search results must not include respectively. After inputting the desired keywords and countries, we demonstrated the results as a list of organizations and their

respective names, URLs, and descriptions. Furthermore, we demonstrated that while the initial list of organizations was limited to the first ten, more organizations could be displayed using the ‘Next Page’ and ‘Previous Page’ buttons. We lastly demonstrated the feature to save the output as a CSV file.

After the demonstration of the website functionality, the team walked through an example of finding a Singaporean nonprofit organization that is interested in real-world learning as this would be the first use case for the employees at Twin Oaks. We selected the *Singapore* location filter, inputted ‘Education’ as a required keyword, and removed results that contained the word ‘Giving’. After hitting *Search*, we showcased the list of organizations displayed on the right-hand side of the screen. We exported a few randomly selected organizations to a CSV file; we explained that this feature would be useful for further processing that they deem necessary.

After the team helped the Twin Oaks employees gain a better understanding of the searching tool, we showed examples of potential organizations and strategies to search for them. We showed that the following organizations *chatteris.org.hk*, *thrivehk.org*, *xcledu.com*, and *sgeduacademy.com* are good options for potential partners. We explained that these organizations emphasize connections to the community and strive to make future leaders. We provided foundation, creativity, design, and innovation as possible keywords for the Twin Oaks employees to use to get similar results. The team explained that layer 1 words are input into the programmable search engine and are more ‘suggestive’, while layer 2 words which are input into the searching tool are ‘required’. Layer 1 words help tune the search results such that websites that contain these words are weighted more or given more significance. Ultimately, layer 1 should not be tinkered with as these words help more desirable search results appear earlier in

the list of search results; this layer has already been tuned. On the other hand, layer 2 words help further restrict the search results by requiring the websites to specifically contain these words.

In general, the employees of Twin Oaks liked the functionality and aesthetics of the website. However, there were a couple of minor issues that were immediately addressed during the demonstration. One of the issues was that the CSV output did not work properly for certain web browsers such as Safari but worked for other browsers like Chrome and Microsoft Edge. We took note of this issue and included this discretion in the user manual. The second issue arose when Twin Oaks employees found that when they tried to open the CSV output file as an Excel spreadsheet, Chinese characters would be translated to gibberish. During the demonstration, we found that a solution to this issue was to first open the CSV file as a pure CSV file, and then convert the file to Excel form. This issue and its solution were also included in the user manual.

4.0 Limitations

The seven-week timespan restricted the development of the partner searching tool. The scope was changed from developing a data crawling algorithm to using an API of an existing search engine. This imposed tighter restrictions on the team as more research had to go into creating a website and implementing APIs, where the focus was on algorithms and big data. One main restriction was the number of iterations the team developed for the tool. The process of developing a website is iterative and repetitive, there was only a minimal amount of changes the team could implement in this time span.

There was a lack of interviews and surveys to aid in the development of the searching tool. Our team planned to interview three WPI professors to gain knowledge about API usages, best education practices, and user-interface design. However, we were unable to get in contact with any of these professors. While our team was able to successfully develop a partner searching tool, these interviews would have helped improve the efficacy of the website. Additionally, user testing is a critical part of receiving feedback about iterations in software development, especially in user interface development. We planned to survey the Twin Oaks employees to receive feedback for the website, but the survey was denied. These surveys would have provided a quick qualitative analysis to supply feedback to improve the searching tool (Lune, Berg, 2017; Farrell, 2016). This resulted in less qualitative information that we could use to improve our prototypes and generate a more substantial product.

Lastly, the API only allows a maximum of 100 results to be displayed per search, this means the maximum number of organizations accessible to the Twin Oaks employees at any given time is limited.

5.0 Conclusions

Throughout the development of the back-end program, the team found approaches that were useful in achieving a successful partner searching tool. We learned that utilizing the Google Custom Search API was an effective solution to obtain search results. This API allowed us to interact with the Google Search Engine through code and allowed us to obtain websites and organizations reliably. We were able to directly filter the search results using certain words and phrases. We also found that a smaller list of layer 1 words yielded better results; a long list of layer 1 words was too restrictive and oftentimes led to no results. Additionally, the website found more appropriate potential partner organizations without restricting the search to web pages labeled according to schema.org. The team assumed that all potential partner organizations were officially registered as NPOs, but this was not the case. We found that there were many partner organizations that were not officially registered as an NPO. Lastly, during the implementation of the location/country filter on our website, we discovered that the location filter setting on the Google API was not fully functional. As a workaround, we found that manually embedding the desired location/country into each query layer helped greatly restrict search results to those in the desired location.

Throughout our iterations of the user interface, the team's design began to converge with characteristics that were like other searching tools. The separated inputs section in a dark background mirrored other websites such as Foursquare. The results themselves were also designed to look like Google's search results since the format is familiar to Twin Oaks Employees. This allows users to easily recognize and interact with the user interface as they already know how the interface works from previous experience. To improve user experience, making designs around convention was found to be optimal because it was easy to implement

and provided a sense of familiarity. To further establish a sense of familiarity, the color scheme was modeled after Twin Oaks's colors and the logo for Twin Oaks was included in the interface. This allowed users to instantly recognize that this tool is the proper tool designed for Twin Oaks and establishes familiarity in users. This design process proved effective and should be implemented again for similar projects.

Implementing safeguards in place to counteract user error can drastically improve user experience as well. In our interface, the implementation of a drop-down menu with locations ensured that users did not have to worry about typos causing issues with the tool's code. To be certain about keywords input into the system, a list of words to be processed allows users to double check that their words are correct and what they desire. If something is wrong, clearing the list is easy and simple for improving the user experience.

A custom searching tool needs to have a means of easily exporting information; the searching tool is not useful if employees are not able collaborate on their findings. The team developed an 'export to spreadsheet' function in the user interface since CSV files are easy to read, evaluate, and present to other employees to accomplish this last minute goal. We recommend future teams to add this feature into their development timeline earlier.

Iteration was one of the most important aspects of this project's development. No interface, API implementation, search criteria, or user guide will be perfect on the first try. Just like how practicing a presentation helps you deliver your material better, trying a design and allowing feedback for improvements is a near-perfect way to improve the design's quality. Since we were short on users to test our design, we counteracted this limitation by maintaining consistent contact with our sponsor and allowing them to constructively criticize our deliverables. Besides weekly meetings with our sponsor, email contact was regularly used to

send updates on our deliverables and to generate very quick feedback from our sponsor. When embarking on a software engineering project with a client, we highly recommend maintaining a constant contact with them for continuous improvements, thereby drastically increasing client satisfaction.

When developing the user manual, the team had found clear examples that aided in our conclusions into creating a useful and simple user manual. During our research, the team found that pictorial communication was best when explaining web applications to a user. The emphasis on pictures helps users visualize and follow instructions better. With that the team explained how to use the tool in steps. We learned that having steps was easier to guide readers along with pictures rather than explaining it into different sections. With creating the user manual, the best approach was to have pictures guide the process with clarifying textual explanation. When developing the section of “Optimizing Search Results”, the team thought that having this section was useful since it gave examples and tips to help employees. Both the examples of potential partners and the suggested keywords act as a reference for employees to start their search. We recommend developing a user manual close to the final iteration of development. This ensures that time is not being wasted on documentation that might ultimately be excluded.

During the live demonstration, the team found that a guided walkthrough of the website was very helpful for the employees of Twin Oaks. We provided the employees with the website link, so they were able to follow along with the step-by-step walkthrough. After we finished the walkthrough and explained how to optimize search results, we reserved some a chunk of time to allow the Twin Oaks employees to explore the website and try out different filter settings.

Additionally, we found it very useful that Mrs. Lin was present while the employees were trying

out the website because she was able to better communicate to her team in Mandarin. Lastly, the sponsor requested that our team record the live demonstration strictly for the use of Twin Oaks.

In short, the success of our application and the usage of Google's Custom Search API for organization searching proves the efficacy of the API for similar niche search spaces.

Additionally, we recommend that groups conducting similar work should first evaluate what makes a good partner in the first steps of development. Earlier evaluations will help focus the project and lead to a better final product. We also emphasized iterative design for all deliverables, and we recommend all teams conducting relevant work to do the same. Most importantly, our tool was able to connect nonprofit organizations and therefore indirectly bring positive change into the world. Our tool will be a catalyst in Twin Oaks's educational reform mission by connecting them with organizations to ultimately reach students who need help developing new, modern skills.

Table 1: Project Schedule

| Tasks | Responsible | Week | | | | | | |
|--|---------------|------|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Search Criteria Research | All | ■ | ■ | | | | | |
| Google API Implementation | Eren | | | ■ | ■ | ■ | ■ | |
| User-Interface | Connor | | ■ | ■ | ■ | ■ | ■ | |
| User Manual (Includes Process Documentation) | Tiffany, Adam | | | | | ■ | ■ | ■ |
| Live Demonstration | All | | | | | | | ■ |

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Appendices

Appendix A: Initial Interview with Mrs. Maggie Lin

Purpose: Interviewing the founder of Twin Oaks, Mrs. Lin, helped set the framework of what the algorithm should be expected to accomplish. Additionally, the interview provides context for the scope of companies and individuals of whom our algorithm will be interacting with.

1. What makes a good partner?
 - a. While a good partner is difficult to define, we are looking for a large local Hong Kong or Singapore organization that has good networks with schools and government and is capable of funding its own marketing campaigns. The organization should be a nonprofit organization in education and is willing to promote critical thinking. Ideally, the organization has done past nationwide events and is a local big brand.
2. How do you want to incorporate human searching in our algorithm?
 - a. The human searching component will essentially consist of cross-checking the quality of the search results from the data crawling algorithm with the results of manual google searching.
3. Is there any programming platform that you desire? (Language, Any database)
 - a. Python can be used, but keep in mind that the user will be interacting with a web page, so any python scripts must be hidden from the user.
4. Do you have available databases/datasets for us to look at to help train our algorithm?
 - a. We do not have any databases. If we did, then we wouldn't be asking you for help!
5. What is your expected meetup schedule during D term?
 - a. In terms of a weekly meeting schedule, meeting two times per week would be ideal.
6. Are we working strictly with English or need compatibility with other languages?

- a. For now, English is fine since Hong Kong and Singapore citizens know English.
However, we are planning on expanding to Japan and Korea, so it would be a great bonus if no Japanese and Korean compatibility is implemented.
7. Who will be the ones using the algorithm? Will there be any other stakeholders with this algorithm?
 - a. Twin Oaks staff will be the ones using the algorithm and the web page; They will be used to find global partners to collaborate with Twin Oaks.
8. Are you and/or others at Twin Oaks willing to partake in Interviews and Focus groups throughout D term to help incrementally improve our algorithm?
 - a. Yes, feel free to interview my team. However, please note that I (Mrs. Lin) will be the best resource for determining what this project needs to look like.
9. What would you like to see as a finished product?
 - a. In terms of how people will engage with this project, a web page would be a good final goal interface. Users would be able to provide keywords and filters to narrow their searches, so please make it user friendly. Additionally, we expect to receive a list of only the top results, rather than an entire list of possibilities.
10. What do you hope to achieve with this algorithm?
 - a. The *See Think Wonder* Challenge is a pilot test, so we can work out the potential risks involved. Therefore, we need to identify the perfect partner. Whether or not the project turns out to be a modeling tool (where the algorithm attempts to learn what a good partner is) or a manual double check system (where the algorithm finds a list of partners based on a list of criteria and people will cross-check with manual google searches), the quality of the results will still need to be evaluated manually.

Appendix B: Twin Oaks Partner Searching Tool User Guidebook



Twin Oaks Partner Searching Tool User Guidebook

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Throughout this document, the pictograms below are used to underline points or important notion

1. WHAT IS THIS TOOL FOR

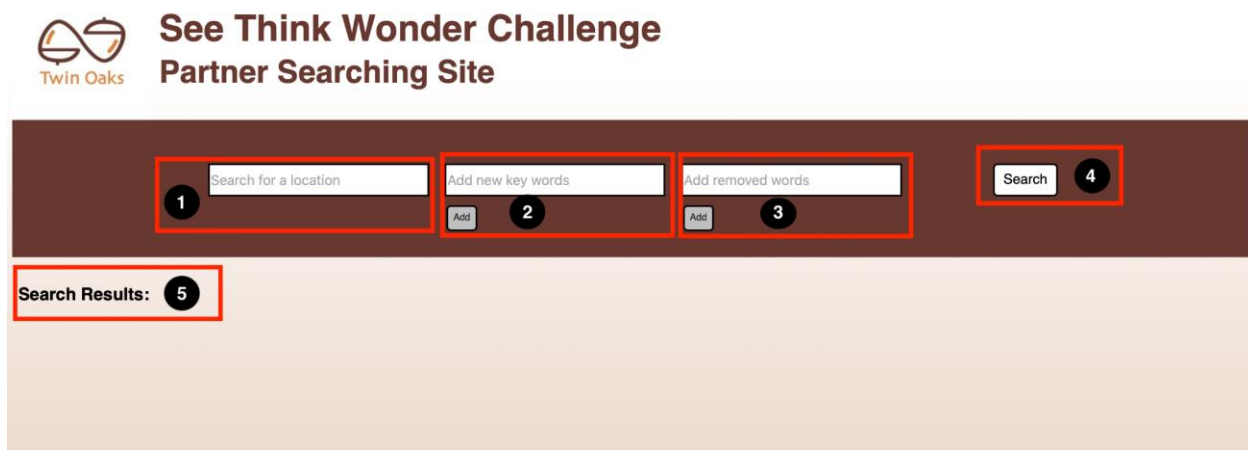
This guide will explain how to use the searching tool to find ideal partners globally to expand See Think Wonder Challenge into new regions. The partners' main job is to promote the Challenge locally. Therefore, we want to look for partners which have good connections with local high schools, education bureaus, and local education foundations.

2. HOW TO USE THE TOOL?

For daily use, go to the “General User” section. If you are an engineer who wants to edit the codes/API, please go to the “Engineer Use” section.

2.1. General User

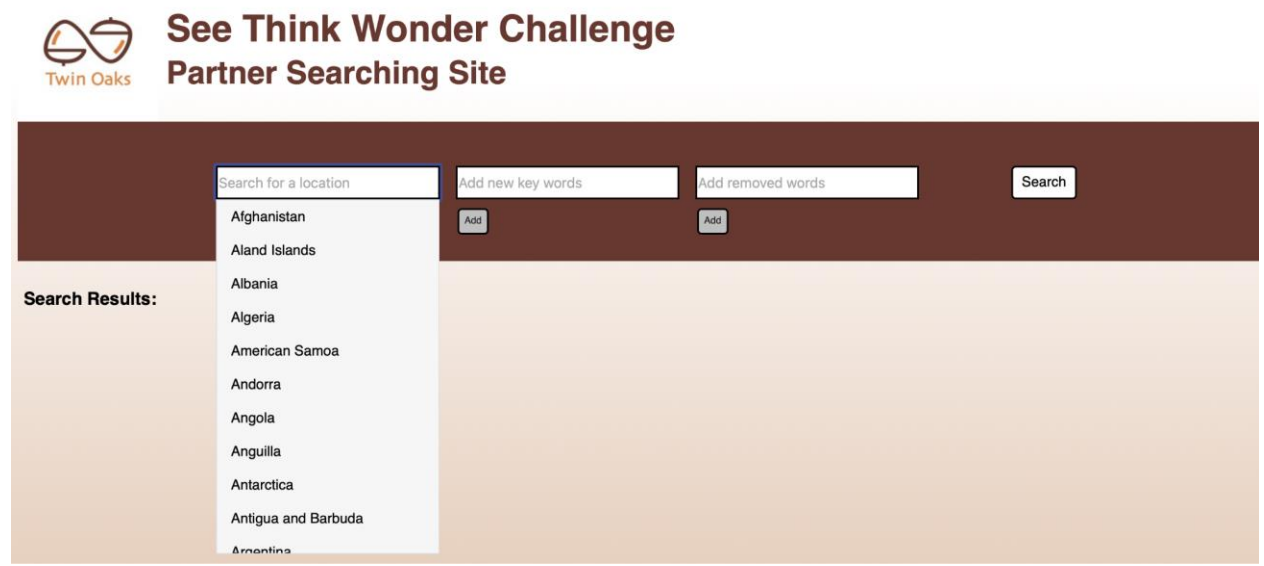
2.1.1. Features of the Website



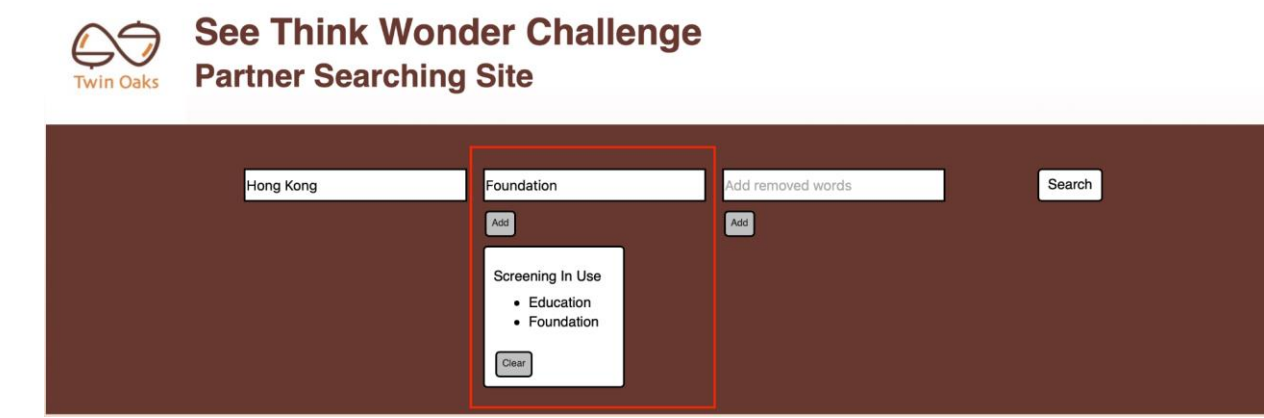
1. Country and Region: Select/Input region
2. Add New Key Words: Input screening words
3. Add Removed Words: Input screening words to exclude
4. Search Button
5. Search Results: Populates search results and website links

2.1.2. Screening and Getting Results

1. Type in the country or select the country from the dropdown list.



2. Add new screening words for search into the text box.



3. Add screening words to be excluded from the search (in the red box). Press the search button when the user is done inputting screening criteria.

The screenshot shows the search interface for the See Think Wonder Challenge Partner Searching Site. At the top left is the Twin Oaks logo. The main heading is "See Think Wonder Challenge Partner Searching Site". Below this, there are three input fields: "Hong Kong", "Foundation", and "Add removed words". The "Add removed words" field is highlighted with a red box. To the right of these fields is a "Search" button, also circled in red. Below the input fields are "Add" buttons for each. A "Screening In Use" section is visible, listing "Education" and "Foundation" with a "Clear" button below it.

4. Results will populate at the bottom. The blue text is the website link. The add spreadsheet button adds the website/organization into an excel sheet.

The screenshot shows the search results page. The heading is "Search Results:". There are three search results listed. Each result includes a blue hyperlink for the organization name, its website URL, and a brief description. Below each description is an "Add to Spreadsheet" button, which is circled in red in the first result. The results are:

- Hong Kong Pei Hua Education Foundation**
www.hkpeihua.com.hk
http://www.hkpeihua.com.hk/en/index.html
The Hong Kong Pei Hua Education Foundation is a non-profit-making private organization. Its objective is to help China train up competent personnel.
- Yew Chung Education Foundation**
www.ycef.com
http://www.ycef.com/en/
We are a Hong Kong pioneer in global education, bringing together the best of the East and West. With almost 90 years of service, we continue to forge new ...
- Hong Kong University Graduates Association Education Foundation**
www.hkuga-ed.org.hk
https://www.hkuga-ed.org.hk/
The vision of the Hong Kong University Graduates Association Education Foundation is to educate the younger generation for the future through the promotion ...

5. There are 10 results per page. On the bottom, users can click "Next Page" to view more results as well as go back to previous pages.

[English Schools Foundation | 22 International Schools in HK Home ...](#)
www.esf.edu.hk
<https://www.esf.edu.hk/>

English Schools Foundation - the largest English-medium international school organisation in Hong Kong. Our 22 sch

Total Results: 472000 **Page: 1**

6. Once users find organizations that are potential partners and add them to the spreadsheet. Click save spreadsheet to export all added organizations from search to an excel file.

[ation | 22 International Schools in HK Home ...](#)

1 - the largest English-medium international school organisation in Hong Kong. Our 22 schools and comprehensive programme of ...

Page: 1

Note:

1. Safari is unable to load the spreadsheet. Browsers such as Chrome and Edge would allow this feature to work.
2. When converting to excel, Chinese characters might not translate and will be denoted as random characters and symbols.

2.2. Engineer Use

2.2.1. Use the API

The website is linked to the Google Programmable Search Engine to customize web searches and refine the search for more filtered results. This API provides built-in customization and screening that users do not have to make on the website. Depending on future needs, the API's built-in customization can be changed.

2.2.2. Important Features

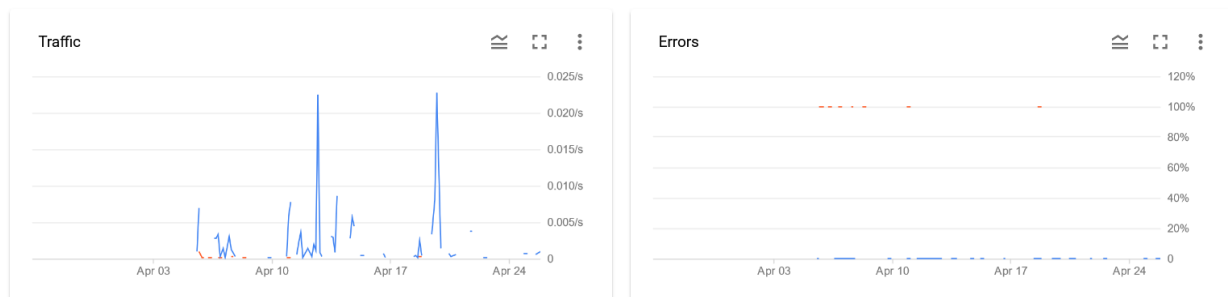
2.2.3. Search Engine Keywords

Search engine keywords ?

'education' 'nonprofit'

These search engine keywords determine the layer one screening to gear the results towards education organizations. To change the keywords, type in the new word in single quotations or delete the words in the text box.

2.2.4. API Control Panel



This page (console.cloud.google.com) provides analytics for the APIs usage. Additionally, billing can be changed on this site.

2.2.5 API Inputs and Outputs

There are several inputs that are variable to the API. The most important ones are q, which is the query itself. Cr and gl are responsible for the location the search is taking place in. More documentation can be found at: <https://developers.google.com/custom-search/v1/reference/rest/v1/cse/list>

These variables are passed into the URL of the API request as follows:

```
var url = "https://customsearch.googleapis.com/customsearch/v1?key=" + key + "&cx=" + cx
+ "&q=" + q + "&cr=" + "country" + gl + "&exactTerms="
+ exactTerms + "&orTerms=" + orTerms + "&gl=" + gl
+ "&start=" + sessionStorage.getItem("search") + "&hq="
+ hq + "&excludeTerms=" + excludeTerms + "&callback=hndlr";
```

The response is then handled in the hndlr function since callback=hndlr. This function is in the index.html file and is responsible for displaying the API return call.

The response will be a JSON file following the Search format posted here:

<https://developers.google.com/custom-search/v1/reference/rest/v1/Search>

3. OPTIMIZING SEARCH RESULTS

3.1. How to identify good organizations

While there is no exact definition for what a good potential partner looks like, some general characteristics are:

- Education-oriented.
- Aims to create/encourage future leaders
- Has good connections to local communities

Here are several examples of good potential partner organizations and their reasons:

1. Chatteris Educational Foundation.



partner schools across three different age groups: primary, secondary and post-secondary. We also run short courses for schools, experiential learning opportunities for students, and deliver multiple community outreach initiatives to serve less privileged groups in Hong Kong society.

Chatteris is education-oriented and has great connections to local communities in Hong Kong.

2. Thrive Hong Kong



and youth education charity. We envision to turn under-resourced children and youth into self-confident and positive future leaders who are motivated to give back to the Hong Kong society. It was co-founded by Ms. Polly Chan &

Thrive HK is education-oriented and aims to create future leaders.

3. XCL Education



Our mission is to produce the best outcomes for our students, not just with excellent, world-class academics and co-curriculars, but also with the tools, mindset, and exposure they need to confidently navigate the uncertain future, find their own place, and leave their own mark in the world. It is to prepare our students for the jobs of tomorrow.

XCL is education-oriented and aims to create future leaders.

4. Singapore Education Academy



Singapore Education Academy (Asia Pacific) Pte Ltd or SEA is the holding company for the Group's education businesses. The Group Companies have developed software to market to K-12 schools, after school tutors /companies. We have also developed professional development courses for tutors. The companies' business interest spans geographies of Asia Pacific and beyond.

SEA is education-oriented and has many connections to local communities in the Asia-Pacific region.

3.2. Useful Search Keywords

Some useful keywords that can help yield desirable results are as follows:

1. Foundation
2. Creativity
3. Design
4. Innovation
5. Education*

* While it is already in the Layer 1 list, putting “Education” in Layer 2 ensures that the search results contain the word “Education”. This is further explained in the “Definition of Screening Layers” section of the Appendix.

4. APPENDIX

4.1. Definition of Screening layers

Screening Layer 1 is more “suggestive”:

- Helps tune the search results; websites that contain these words are weighted more and given higher significance. Websites with these words will appear earlier on the list of search results. This layer should not be modified as it will change all further API requests.

Screening Layer 2 words are “required”:

- Helps further restrict the search results by requiring the websites to specifically contain these words. This layer should be changed as they are the primary function of the tool.