REPORT

As a partial requirement for the course on

Interactive Qualifying Project

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Designing a New Library Space in line with a Carbon Neutrality Certification for CCCN

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Abstract

El Centro Cultural Costarricense Norteamericano (CCCN) located in San José, Costa Rica, provides English courses to students as well as cultural experiences through theatre, artwork, and technology. CCCN has been working to become a carbon neutral organization while completing large renovation projects at their San Pedro campus. Our team provided redesign and renovation suggestions for their library space to create a sustainable and innovative library that also supports CCCN's pursuit of carbon neutral certification.

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Executive Summary

Purpose

The Centro Cultural Costarricense-Norteamericano (CCCN) has been working to decrease its carbon footprint for numerous years. They have been trying to become Carbon Neutral through the implementation of solar panels and the purchasing of green supplies. The CCCN tasked us with continuing their efforts to obtain a Carbon Neutral certification. As CCCN plans to remodel the San Pedro location, they needed to ensure that their campus stays green and continues them on the road to Carbon Neutrality. As part of the campus renovation, they have a goal to redesign their library, following green standards while simultaneously creating an interactive space that is technologically advanced and can engage their wide range of users.

Goals, Objectives and Methodology

The original goal of this project was to create a roadmap that would help CCCN achieve a Carbon Neutrality Certification as well as recommendations for future classroom designs. In particular, CCCN wanted us to redesign their library space into an interactive learning environment that would attract people of all ages.

Our first objective was to identify a company that could give CCCN a carbon neutral certification once they satisfied the requirements. Since there are so many different Carbon Neutrality certifications, we were charged with finding one that would fit the standards that the

CCCN meets. Our second objective was to create a blueprint for the library redesign. This included creatively deciding on different spaces and finding companies that could furnish the library with technology, furniture and sliding partitions. However, this portion of the project should not prevent CCCN from achieving their carbon neutrality certification as that remains a major goal for the center. The methods to reach these objectives were mainly through meetings and interviews with our sponsors, finding what spaces they wanted to include in the library's redesign and what concepts intrigued them. We identified companies that could provide the products that CCCN was looking for, whether it was modern furniture, movable glass walls or interactive technology by online research.

Results and Analysis

We provided CCCN with an initial floor plan from each of the members of the team where we collected the thoughts and opinions of CCCN's academic team. From the first round, we tried to implement as much of the feedback that we heard into a final round of three floorplan options with differing strengths to offer.

As an answer to CCCN's desire to create a library space that could be open concept and modern on most days but sectioned off for different groups to do different loud work on others, our team found retractable partition walls for the campus to choose from in their remodeling. In the end we found four companies with glass partition walls that we felt could satisfy the need in different ways. All the options we provided had distributers local to San José to reduce costs of shipping.

Along with defining spaces, we also found technology options to outfit the library renovation. The three main pieces of technology needed by the CCCN are gaming equipment, virtual reality headsets, and touchscreen tables. We reached out to a company that could sponsor the creation of an E-Sports area at CCCN. In addition to this, we also compiled a recommended list of gaming equipment, including computers, monitors, keyboards, and mice in case the sponsorship would not work out. Regarding the virtual reality headsets, we picked out two products that meet the requirements of the CCCN, with portability as the focus. For touchscreen tables, we found a company in the United Kingdom that specializes in touchscreen furniture: Pro Display. They offer a multitude of different sizes, allowing CCCN some flexibility in the layout of the tables depending on the budget. Another option is to inquire about installing touchscreen tablets inside custom-made desks from the companies that will be providing the furniture for the library.

To round out the outfitting of the library, we found several furniture suppliers to fill the library space. We found three different possible suppliers for CCCN to choose between selling a range of furniture styles, qualities, and products. In addition, two of the companies we found had green certifications for their manufacturing processes, to align with the sustainability aspect of our project.

We researched a few different Certification bodies here in Costa Rica that we though we fit for CCCN’s Carbon Neutrality certification needs. The two we landed upon are based in the San Pedro district in San José. One was the Carbon Neutral Country Program 2.0 presented by

the Dirección de Cambio Climático. The other was Instituto de Normas Tecnicas de Costa Rica (INTECO) which is a government standardization body in Costa Rica.

Conclusions

When it comes to recommendations, we narrowed it down to a single company for each aspect of the library. For sustainable furniture we recommended VS America due to its modern look, sustainability certifications, and ability to create custom work and a learning staircase. For the sliding glass walls we proposed Hawa Sliding Solutions as they provide a unique motorized wall that has a door opening. Regarding the gaming equipment, we recommend pursuing sponsorship with iBuyPower to receive quality equipment at a low cost. Concerning the virtual reality headsets, we recommend the Oculus Quest 2 for its portability and value. As for the touchscreen desks, we recommend the Pro Display desks because they can be used in a variety of scenarios. In respect of carbon neutrality, we recommend the Carbon Neutral Country Program 2.0 for its locality, positive review, and flexibility in certification levels.

Chapter 1: Introduction

Since the 1800s, industrialization has impacted the global climate in major ways. The effects on the climate reach further than warmer temperatures; the impacts could be as serious as frequent wildfires and droughts, melting of ice at the poles resulting in major sea level rise, more severe storms, and a dramatic decrease in biodiversity (Nkemdirim, 1997). Most of these effects are directly related to the increase in carbon dioxide and other greenhouse gases in our atmosphere. Due to the dangerous effects of global warming, countries around the world have come together to try to decrease their carbon footprint: the amount of carbon they release into the environment per year.

Costa Rica is not an exception to society's negative effects on the environment. A major contributor to carbon dioxide increases in this small Latin American nation has been deforestation (Nygren, 1995). Between 1940 and 1990, Costa Rica had decreased its overall forest cover from 75 percent to 29 percent. The negative effects of deforestation include soil erosion and increased carbon dioxide in the atmosphere because there are fewer trees to capture it. To this day, Costa Rica is still trying to overcome the effects of the mass deforestation that occurred in the twentieth century. Through governmental policies and individual actions, Costa Rica has started on its path toward becoming Carbon Neutral, but they still have a long road ahead of them.

The Costa Rican government has recognized the threat that global warming poses to the environment and has developed a comprehensive plan to become "carbon-neutral" by 2050 with

tangible policies (Mora, n.d.). The National Decarbonization Plan looks to reform transportation, energy, waste, and land use while disincentivizing the use of fossil fuels. To help decrease their overall emissions, companies must also start to individually decrease carbon emissions from each room in their buildings. Moving towards Carbon Neutrality Certifications by reducing building emissions has also been a focus of many companies around the world ("44 businesses announced…," n.d.).

Costa Rica has come a long way on the road to carbon neutrality but still has hurdles to overcome. Costa Rica's transportation sector still makes up 54% of its emissions, needing a large reduction if they want to reach their goal of carbon neutrality (Timperley, 2020. In recent years, El Centro Cultural Costarricense Norteamericano (CCCN) has made consistent efforts to become more environmentally conscious, striving towards a Carbon Neutrality Certification (Baker et al., 2021) In order to do so, they must decrease the emissions related to the use of their classrooms and the popular library, which they are looking to outfit with all new technology In their project to remodel the library, they are looking for a way to save energy while enhancing studying habits with a new design. In creating more sources of carbon offsets, they would be closer to their goal of certifying their buildings and campuses as carbon neutral.

The CCCN has tasked us with providing recommendations for a certifying body to work with that would provide them with a carbon neutral certification. In addition, we were given the objective of providing recommendations for the floor plan and outfitting of a new library space. We completed this project through a series of interviews, consultations, literature review, research about the certification process, and what faculty want in their new library. When

completed, this project should put the CCCN in a position to receive certification from a certifying body due to their past efforts to decrease their carbon footprint. This project should also provide several blueprints for the new library along with recommendations for technology, furniture, and retractable walls for CCCN's directors to pick and choose from. The redesign should create a modern, user friendly, and comfortable space for any of CCCN's visitors to enjoy.

Chapter 2: Background/Literature Review

The CCCN is dedicated to doing their part in eliminating carbon emissions from their campuses, but they are a couple steps away from reaching their goal of carbon neutrality. This chapter provides the background necessary to understand the problems the CCCN faces. We describe the global situation due to climate change, and later focus more specifically on how Costa Rica itself has been affected. This chapter also discusses carbon neutrality, including how it is defined, how to achieve it and what organizations around the globe, as well as the CCCN, have already accomplished in trying to achieve carbon neutrality. Finally, we discuss how universities around the globe have used these green options to create better study spaces for students that can increase productivity and lead to better learning.

2.1 General Effects of Carbon Dioxide Increase

According to the United Nations (2021), climate change refers to long-term shifts in temperatures and weather patterns. At times, this can be a natural development, but since the 1800s, human activity has accelerated the process. The decade between the years 2011 and 2020 was the warmest on record thus far. The carbon dioxide released into the environment plays a major role in this change in climate. Earth's atmosphere has what is considered a "greenhouse effect", trapping most of the sun's rays and radiation, being able to maintain temperatures that are suitable for life (Nkemdirim, 1997). The increase in carbon dioxide in the atmosphere does not allow the excess trapped heat to escape, increasing global temperatures (Anderson, 2011).

The burning of fossil fuels along with deforestation and other human activities have caused a dramatic increase in the release of carbon dioxide and other greenhouse gases into the atmosphere. These shifts in temperatures, also known as global warming, can cause extreme changes to ecosystems around the world. These warming patterns have caused a severe change in precipitation patterns, decreasing rainfall in the subtropics, and increasing rainfall in the tropics but also in areas of moderate climate. This can strongly affect environments and their inhabitants. In regions with decreased rainfall, droughts can affect plant growth and lead to a decrease in biodiversity. This not only affects the wild plants and animals living in that area, but also the people who rely on the farmed food in these areas.

Another clear indicator of the rise in global temperatures is melting ice caps and glaciers. According to the IPCC, the arctic could have no summer sea ice by 2070 (Anderson, 2011). The melting of the icecaps is catastrophic because not only do ice caps help keep the atmosphere cooler, but they also keep the sea level lower. The global sea levels have already significantly risen, potentially causing damage to many environments on continents' and islands' coastlines. If the melting continues at this rate, the oceans could submerge entire islands and cities (Nkemdirim, 1997).

2.2 Carbon Neutrality

Carbon neutrality refers to the amount of carbon released by a certain action or operation as being net zero. One way to achieve this is by using renewable sources of energy that do not need to burn fossil fuels. Using sources such as solar power for buildings allows for energy

production without releasing carbon emissions, keeping carbon emissions to a minimum. Carbon Neutrality is the net-zero carbon dioxide emission from a process or location. Companies can become carbon neutral in two main ways. The first, and more traditional, way to become more carbon neutral as a company is to reduce their carbon output such as reducing waste, recycling, or running their electricity from solar panels or other renewable energy sources. Recycling and waste reduction helps keeps the energy consumption from production low because it negates the need for a new product to be produced as a replacement (Fendt, 2015). The second is by investing in a carbon offset program. Vendors will sell carbon credits for taking in more carbon from the environment than they output. It is common for companies that produce renewable energy to sell their carbon credits.

In 2015 Costa Rica vowed to become carbon neutral by the end of 2021, which is an incredibly ambitious target (Mora, 2021). The country has made huge strides to try to meet this goal. As one of the first and more productive nations to implement a policy that would fight climate change, Costa Rica now has more than 98 percent of its energy coming from a renewable source and more than 53 percent of the land has forest cover. The transport sector in Costa is responsible for 54% of the greenhouse gas emissions. To help reduce this, the country has created a public bike system for people to rent from and created an urban cycleway as a new and safe means of cycling around San José.

2.3 Effects of Carbon Dioxide Increase on Costa Rica

Costa Rica's government has made a proposal to become carbon neutral as a country by 2050 (Mora, n.d.). Though Costa Rica is one of the leading nations in its tangible plan to minimize its carbon output, this Central American country is still at serious risk of the effects of climate change. Costa Rica has several different ecosystems since some regions of the country are at sea level, whereas other areas, such as the Monteverde region - which is about 6,000 feet above sea level (Monteverde Info, n.d.) - are at high elevation. At high elevation, rising air creates a layer of clouds that nourish the vegetation and allow for life. Much of the mountain's biodiversity depends on cloud forests, a cloud layer that covers the mountains and keeps the environment moist throughout the dry seasons. According to a study performed at the University of Massachusetts Amherst, if carbon dioxide keeps increasing at the rate it is now, the temperature could rise drastically, and the highlands could receive up to 30% less precipitation (Karmalkar et al., 2011). Changing ecosystems will cause the migration of species to other regions where they could be comfortable and will result in disturbing or even eliminating other species.

The threat to these ecosystems in the tropical forests of Costa Rica can be traced back to the urban cities of the country, such as its capital: San José. For many years now, ecologists have used lichen - a plant that tends to grow on rocks, trees, and walls – as a means of studying air quality around the globe (Monge-Nájera et al., 2002a). By observing the amount of lichen life in an area, ecologists can determine the levels of air pollution in different areas. A group of scientists studied lichen coverage on trees in different areas around Costa Rica to determine what

was a detriment or source of life for the plant species. One of the most important results of the study was that the group found lichen coverage to be linked to carbon dioxide levels. The data found that in areas with 27,000-40,000 cars per day, the lichen coverage was low. On the other hand, in a region with 18,000 cars per day, the lichen coverage was high in 1976. However, when this region's traffic density rose to 25,000 vehicles per day by 1990, much of the lichen coverage had disappeared. This data directly links an increase in carbon dioxide in the air being harmful to the environment, especially plant life. A statistic from the the US Environmental Protection Agency further links traffic density to carbon dioxide in the atmosphere (Greenhouse Gas Emissions from a Typical Passenger Vehicle, 2018): A typical passenger car emits roughly 4.6 metric tons of carbon dioxide every year.

2.4 Achieving Carbon Neutrality Certification

The CCCN is aiming to gain a Carbon Neutrality Certification for their campuses. They will need to get this certification from the Carbon Neutral Country Program (Baker et al, 2021). The Carbon Neutral Country Program is a governmental authority formed to oversee procedures related to reports of greenhouse gas emissions. They ensure that the measurements and reports have reliable data collection. Instituto de Normas Tecnicas de Costa Rica (INTECO) and the Carbon Neutral Unit of EARTH University are the two verifying/ validating bodies for the Carbon Neutral Country Program in Costa Rica. They ensure that products and services provided by companies are up to standards set by INTECO. The standards exist for organizations to help reduce their own waste while increasing efficiency. They divide their standards into two

categories: Environmental and social standards. Environmental standards refer to environmental regulations that need to be followed, and they give the management sector of a company the framework to manage the impact of their decisions on the environment. Social standards relate to the social responsibility policies that companies should abide by.

2.5 Calculating Carbon Footprint

When calculating a building's carbon footprint, we need to consider all the things that contribute CO_2 emissions from the building during its operational stage. Estimations are done by third party certification agencies who will be contacted come C-term. These estimations encompass 3 different scopes of carbon emissions. Scope 1 is the emissions from all the controlled resources like emissions from production, etc. Scope 2 is the indirect emission from electricity and heating and cooling systems. Scope 3 is the miscellaneous emissions that are not directly related to the company such as their investments, travel, and waste. This waste can either be measured in units of mass or volume. Then, the scores of each of those scopes is multiplied by an emission factor, which is dependent on the type of emission, to the common unit of greenhouse gas (GHG). The CCCN has eliminated all Scope 2 emissions with their use of solar panels on their roofs (Baker et al, 2021).

2.6 Small Scale Carbon Neutrality

Several private entities in Costa Rica have taken it upon themselves to reduce their carbon output. Coopedota R.L., a coffee producer in San José, has become a pioneer in achieving

carbon neutrality in the agri-food industry (Birkenburg & Birner, 2018). Coopedota became the first cooperative in the world to certify their coffee as carbon neutral based on a widely recognized international standard. They are also the first to achieve a PAS 2060 certification outside of the European Union. The PAS 2060 certification builds on PAS 2050 and ISO 14001 certifications and contains a rigorous set of standards to meet compliance (see Appendix D for PAS certification information).

Many factors make this example a valuable source of knowledge about achieving carbon neutrality. Not only is coffee one of the most traded food products worldwide, but it is also one of the largest producers of greenhouse gasses, responsible for 9% of Costa Rica's greenhouse gas emissions (Birkenburg & Birner, 2018). The primary sources of these emissions are chemicals used to fertilize the soil and the organic waste from production. Coffee is also particularly affected by climate change, so coffee farmers must reduce their emissions before it is too late. Bunn et al. predict that half of the area suitable for coffee production worldwide will be lost by 2050 due to climate change (2014).

The PAS 2060 certification is not the first attempt that Coopedota has made at carbon neutrality, however (Birkenburg & Birner, 2018). They had a number of pre-achievements, such as ISO 9001 and 14001 certifications, as well as applying Good Agricultural Practices (GAP) (see Appendix B for ISO certification information). From this example, we can conclude that organizations that are already practicing green behavior can expect to have an easier pathway to certification.

Another organization that has made great progress towards becoming Carbon Neutral is a recycling facility in Chicago (Graf, 2016). This metal recycling facility has made three main steps towards this certification, using a greenhouse gas management policy to reduce onsite emissions, increasing the use of renewable energy, and using voluntary emission reductions to offset greenhouse gases. Through annually measuring their carbon output, they have been able to compare methods from previous years and decide what has been working for them. The main struggle with achieving perfect carbon neutrality is the offset. This company put a lot of effort into offsetting their emissions by purchasing Renewable Energy Credits (REC's) and Voluntary Emission Reductions (VER). RECs are energy certificates that prove how much electricity was generated from a renewable energy source per year. VER is the offset of carbon emissions such as by purchasing the planting of trees on private land to decrease emission in the atmosphere.

2.7 Centro Cultural Costarricense-Norteamericano (CCCN)

According to their website, the CCCN prides itself on being the leading site for courses in English in Costa Rica (¿Quiénes Somos?: Aprendé en Centro Cultural, 2021). In addition, they educate their students on how the United States and Costa Rican cultures are similar and different. Beyond educational courses, the organization built and maintains the Mark Twain Libraries, the Sofia Wanamaker Art Gallery, the Eugene O'Neill Theatre, and several other resources for their students across three campuses. Typically, the demographic characteristics of the students at the CCCN show they are from underprivileged families because they do not have the same access to the quality of education and resources as do those with money. Through the

CCCN, these students have access to resources they would not have otherwise. In such a large organization, with 186 employees and 5,100 students, there is potential for a negative impact on the environment. The three campuses use water, lighting, electronics, and paper, which are directly linked to the burning of fossil fuels whether it is from the manufacturing processes or from their use. Indirectly, the employees and students typically use public transportation to get to the CCCN.

Figure 1: The CCCN's new solar panels on their San Pedro Campus (elmundo.cr, 2019)

2.8 Building Specific Carbon Emissions

There are many factors that contribute to a building's emissions, but all of them can be controlled to an extent. The first factor that affects a building's emissions is its "Embodied Carbon Emissions" (Fenner, 2020). This considers what materials were used to build the building and the quantity of all of them. Due to its integrated nature, these emissions can be very

difficult to decrease and typically must be calculated before the creation of the building. Products like steel and cement have a high share of emissions due to their energy-intensive manufacturing process. These emissions can typically range from 10-50% of the building's total emissions, depending on the building's lifespan, location, and energy consumption.

Most of a building's emissions come from "Operational Carbon Emissions" (Fenner, 2020). These are related to the consumption of energy within a building, and can be affected by the building's location, occupation type, energy source and the building's systems. Some of the categories that rank highest on this list are air conditioning, lighting, equipment, and appliances. Due to new technology and more renewable energy, these emissions have been on a strong decline in the past decades. One of the biggest factors in this decrease is advanced building envelope design, or insulation. With better insulation, buildings could reduce their heating and cooling demand by 40 percent.

The third contributor to a building's emission is the "mobility Carbon Emissions" (Fenner, 2020). This is the sum of the building's tenants' emissions. Based on the building's use, this can be higher or lower, as the emissions could exceed 30% of the building's operational emissions. This is a growing problem as transportation emissions are increasing. With the increase in vehicle usage across the globe, this will only continue to rise as more people start driving vehicles to work.

When we looked at modern libraries and shared study spaces one of the major contributors to carbon footprint is the electrical requirements for the technology in the space.

These can be reduced by using low wattage LED bulbs and e-ink displays with low electrical requirements. Turning a library mostly digital will help reduce book waste, and the current books can be donated to other libraries to eliminate waste. If a library is hooked up to a buildings sustainable HVAC system, then that will also help reduce carbon footprint (Moore et al., 2018).

2.9 Interactive Learning Environments

As technology advances, better methods of learning are constantly emerging. Moving learning materials from paper to virtual sources can help interactivity while reducing carbon emissions.

One technology that has recently begun being utilized for learning is the virtual reality headset, otherwise known as a “VR headset”. VR headsets are optimal for learning due to their interactive and immersive nature (Petersen et al., 2022). Immersion is an important factor when picking technologies for education because many students learn better when immersed in the material. VR headsets can also be used for other purposes such as gaming or interacting in virtual chat rooms. With the application for libraries constantly expanding, there are plenty of sources of educational content, as well as games and videos. VR headsets have also become more affordable since they were first introduced, with companies such as Facebook and Samsung offering affordable headsets under $500. One downside of these headsets is their possibility of breaking when being put in the hands of young students. This might make some decide to choose a cheaper option so that they have less of a financial burden when the headsets need to be replaced.

Figure 2: Virtual reality headset (Pham 2020)

Another movement that has improved the quality of education is makerspace areas. These spaces help students learn new skills by gaining hands-on experience. Makerspaces are named after the service they offer, with some examples being DJ Studio, Science Lab, Museum as Play, Robotics Learning Lab and Arts Camp (Güneş & Canatar, 2022). The spaces provide advanced technology for people who are working on projects of various subjects. For example, CCCN is looking to utilize this space for students to work with Arduino computers. Arduinos are used for experimenting with hardware and software on a small scale. Through trial and error, these people create products and gain experience. Makerspaces are typically located in areas that are accessible for large groups of people, such as university buildings or public libraries. These spaces are also a good option financially, as they can be affordable or extravagant depending on the client.

Another instance of interactive learning is reading through an e-ink tablet. These are known to require less power to run as well as have health and attention benefits. One concern with traditional LCD screens is that they produce blue light which is unnatural for the eyes and causes strain when reading for long periods of time. The blue light also disrupts the circadian rhythm causing sleeping issues by reducing the brain's melatonin secretion. E-ink displays are not back lit, so they require ambient light. They don't respond to glare the same way as traditional LCD screens, yielding in a very similar experience as reading a real book (insert citation). They also have 36 times the battery life as a traditional LCD tablet of the same size screen. This results in not requiring as much energy to run and help decrease carbon footprint.

2.10 Online Library Resources

As CCCN continues to expand its programs, many of their classes continue to be online, considering students and faculty prefer it, and it is a greener option. They have started to move their files online through Overdrive for students to access electronically. This not only creates easy access for people anywhere, but this is also a greener option in the future with respect to purchasing resources. When classes are being taught virtually it is very important that the students remain engaged and connected to their teachers and the curriculum. In order to do this, the students and faculty need to be made aware of the resources they can access remotely to promote their collective learning. With libraries expanding their online platform, it can create a higher use of evidence-based learning as students and faculty are able to use the library's

resources to specifically target their needs (Faulk et al., 2020). There are a couple of ways to go about implementing these new online systems as an efficient resource center.

The first way would be to create an easy mode of communication between the librarian and the person in need of a resource (Rof et al., 2022). Through an online meeting or chat guide, the librarian can easily guide the researcher to an appropriate list of sources. This can be very helpful for younger or newer students who do not have experience conducting research on their own. This will help them use the library's full potential of texts without suffering a disadvantage by using online learning. A second method of usage would be an online guide that would sort out the references listed based on key search terms. This can be more useful for experienced researchers as they would be able to still use the library's resources to the fullest capacity without the librarian's help. For both methods to be successful, the library needs to have implemented an online system of databases or resources that can be accessed by the public.

A third solution to remote researching could be workshops. This combines the ideas of the librarian's guide with the element of independent research. The librarian could hold sessions that teach the students and faculty research methods, allowing them to slowly ease into independent research without the stress of figuring it all out on one's own. To properly engage all students, the CCCN could create a single mandatory workshop that will teach all their students the basics of database research, allowing them to work more independently.

2.11 Functional and Flexible Library Spaces

For students to use the library resources to their fullest, the library itself must be a high-quality learning environment that facilitates research and information studies. To develop such a space, there are many aspects that need to be included within the design (Robinson, 2006). These features include PC networks, study facilities, teaching spaces, collections, and research spaces. In Vietnam, they have created plans for four Learning Resource Centre projects that are interactive library environments for multiple universities. Through blueprints and layout plans, they have been able to maximize resource usage within the library.

Their first goal was to create an open concept library that would allow students to have access to all the different kinds of information and resources that are provided within the building (Robinson, 2006). To maximize their usage, they have made all the different sections of the space accessible from key traffic areas of the building. This allows students to easily see the resources available to them without needing assistance from a librarian.

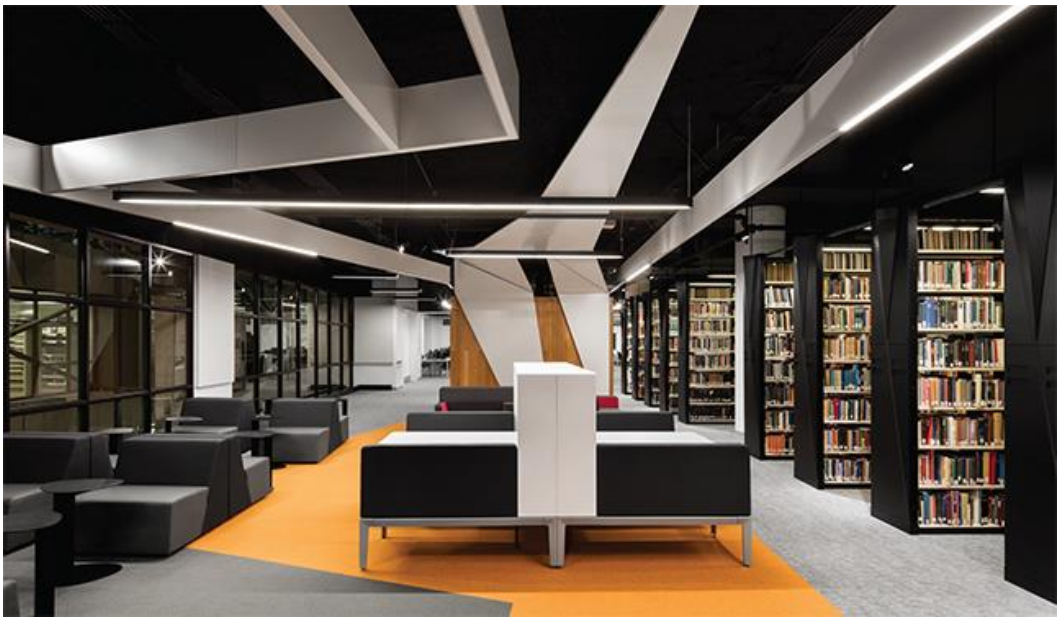

Figure 3: The open space concept of the Hue University Library (Samson, 2019)

For the PC network, they have located it in the center of the floor, encouraging students to use the vast resources available to them such as full text databases, e-books, and print collections. The central location of the PCs also allows for less glare from windows and an easier supervisor role as librarians tend to assist and oversee the usage of these devices. For their physical collections, they have provided shelving along the walls that lets the students easily view and access all the books and materials they would need. To promote studying, they have created isolated study rooms for different purposes that can make the task of focusing easier for students. Some of them are more secluded, quiet rooms that have individual desks for studying, while others have tables and monitors that can be seen from anywhere in the room that promote group work. To divide up these study spaces, the universities have used operable walls that can be used as a flexible means of either dividing or opening a large space. These can also be

essential in providing soundproofing depending on the needs of the situation. For example, the walls can be retracted when a large group is conducting a workshop; however, they can expand again to close off and soundproof an area for a small group study session. The benefit of being able to open the space when necessary is to allow in natural light as well as make all the features of the room visibly accessible from anywhere.

2.12 Past Efforts

The CCCN has been working for many years at an attempt to become carbon neutral (Norales et Al., 2020). To keep up with Costa Rica's carbon neutrality goal, they have completed some major changes to decrease their carbon output. They have installed solar panels on their campuses to decrease the use of fossil fuels as an energy source, in turn reducing their carbon emissions. They have also added recycling bins across their campuses to decrease the waste that goes to landfills. Another initiative they started was the Get Green committee. This committee was formed in hopes of coming up with new ways to decrease their carbon footprint by their own employees and students. The committee has not been extremely successful in the past, coming up with simple ideas such as carpooling or reusable bags. Their recycling idea had a good intention but was not able to reach its full potential due to the lack of knowledge about what can be recycled and what cannot.

In 2020, a research group was also able to establish certain plans to reduce CCCN's carbon emission (Norales et al., 2020). The researchers surveyed the employees, asking them questions about their recycling and commuting habits. From these answers they were able to

narrow down their approach and decide where the CCCN was creating the most environmental waste.

The most recent research group was able to apply Worcester Polytechnic Institute's (WPI) own sustainability program to a carbon neutrality roadmap designed for CCCN (Baker et. al, 2021). This program focuses on academics, campus operations, research and scholarship, and community engagement. The group selected some guidelines from the WPI campus operations and community engagement sections that they deemed a good fit for CCCN's mission. These guidelines include the reduction of utility consumption and waste production and the installation of water bottle filling stations.

2.13 Background Summary

Through research we have found that the best way to calculate a carbon footprint is through an agency that can determine the total carbon output of a business. Governmental agencies can be contacted to start the process of carbon neutral certification. In order to achieve this goal, the CCCN must maintain an extremely low carbon output and acquire a carbon offset program. To guarantee a low carbon profile, the new library could also acquire sustainable technology and furniture. For the library to be an interactive learning environment CCCN could provide new technology such as e-ink tablets, VR sets and research computers that will keep the students engaged and provide resources for their learning. An open space model is the best way to ensure that many different learning environments can be made available to many different age groups. For CCCN to complete this library, they will need to find companies that can supply the

technology and furniture that would create an interactive learning environment as well as decide on the different spaces to include.

Chapter 3: Methodology

The goal of this project was to identify improvements in CCCN's library, and their three campuses overall, that will help CCCN to obtain an ISO 14001 carbon neutral certification. To attain this goal, we developed a list of objectives for us to achieve that will bring CCCN closer to their ultimate goal:

1. Calculate carbon output of San Pedro and compare them with the data from 2021; this will help us determine how close they are to the certification and in what areas they need to improve.
2. Provide purchasing recommendations for the design and furnishing of an interactive library. With the guidance of the recommendations, CCCN would be able to create a new library in such a way that will decrease their campuses' carbon footprint.
3. Design the blueprints for the renovation of their library that integrates spaces for collaboration as well as individual work. The objective is to create a modern space for digital learning and use environmentally friendly products where possible.

This chapter describes the methods that we used to achieve these objectives.

3.2 Certification Recommendations

One of our main objectives was to give recommendations to CCCN that could advance their progress towards an ISO 14001 carbon neutral certification. Our first step in achieving this

was to identify and understand the ISO 14001 certification requirements (see Appendix B for ISO certification information). The next step we took was to find improvements that we could make to their buildings and classrooms to reduce the carbon footprint of the organization. We acquired most of the information for these recommendations through a series of interviews with employees at CCCN as well other organizations around Costa Rica (see Appendix C for interview procedure). Using this information, we examined specific areas that have a significant impact on the environment at CCCN campuses. This includes utilities such as water, electricity, and gas, as well as waste generation and air emissions. By evaluating their environmental impact in simple ways such as these, we were able to develop a fundamental set of recommendations that can create a strong foundation for obtaining an ISO 14001 certification at CCCN. We then combined these recommendations with a broader set of findings to generate an extensive compilation of recommendations that CCCN can follow to help them acquire an ISO 14001 certification. In order to attain a Carbon Neutral Plus certification, we passed along information about the application process and a list of documents that were required by the climate change directorate.

3.3 Reducing Carbon Footprint

The CCCN has a long way to go to reach carbon neutrality, but through many efforts they could decrease their carbon output drastically. As mentioned in the last section, we calculated their carbon output for the previous year. Once we achieved this calculation, we identified different areas in which CCCN is outputting most of their carbon. Based on the different areas,

we provided suggestions to decrease it while being mindful of what other businesses and buildings have done in the past. We have already conducted research on such organizations and will continue with more literature review.

In 2022, CCCN planned to move back to using hybrid classes. This drastically changes their carbon output, initializing more consumption on campus of both materials and energy. Our goal was to help the CCCN so that they do not have a drastic increase in their carbon footprint once in person courses begin.

3.4 Designing an Environmentally Friendly Library

To design a library with minimal carbon footprint, we conducted our own research and interviewed experts in the field of sustainable building design to find products that were environmentally friendly. The experts that we connected with include people who have been involved in the design of environmentally friendly buildings and product suppliers. On the WPI campus, we interviewed the head of the Sustainability Committee. As for product suppliers, we got in contact with suppliers across the globe that had certifications verifying their sustainable manufacturing practices. The products that we focused on include furniture, lighting, and technology for students and teachers to use. This included the materials used to make the products, how they were manufactured, and the energy consumption of the lighting sources and technology. This section outlines the process we went through to be able to provide the CCCN with a recommendation outlining how to design their library renovation that would aid them in their mission to become ISO 14001 Carbon Neutral certified.

3.4.1 Interviewing Experts: How to Design Environmentally Friendly Buildings

Across the world, there are numerous valuable examples of building designs that make a conscious effort to have the least possible negative effects on the environment, including some that are carbon neutral certified. There have been efforts on the Worcester Polytechnic Institute campus to implement features to existing buildings and design new buildings to minimize the campus's carbon footprint. To get an idea of how the campus and other organizations have attempted this, we interviewed experts on the matter. These people included members of campus sustainability committees as well as information technology experts. The first interview we conducted was with the head of the WPI Sustainability Committee. When reaching out to the interviewee, they were briefed on the general topics of our interview and asked if they are willing to be recorded and quoted. During the interview, we began by asking if they are willing to have the conversation be recorded and be quoted. These actions were to assure that the interviewee was comfortable and aware of our intentions. We asked them questions surrounding the type of research they did to decide on products to purchase for the interior design of said environmentally friendly or carbon neutral building. A copy of the interview questions and protocol is included in Appendix C. This interview followed the same protocols; however, the goal of the interview was to get an understanding of how the WPI campus has worked to remain sustainable while consuming more energy as the campus integrates more technology. In addition, he provided us insight on measures to take that would support the internet requirements for research and gaming computers.

3.4.2 Environmentally Friendly Light Fixtures

A major source of a building's carbon footprint comes from its electricity usage. The last project group to assess the CCCN's carbon footprint per annum found that electricity was the greatest contributor (Baker, 2021). Different types of light fixtures can influence the electricity usage. For that reason, we determined what different types of light fixtures are available on the market in San José and what their varying carbon footprints are to decide what we should recommend to our sponsors. First, we spoke with the head of the Sustainability Committee on campus at WPI to learn about what WPI does for lighting of the buildings and whether there are better options. We also spoke to the building manager at CCCN to get an understanding of the lights they currently use and whether they are the best option. The interview questions and protocol can be found in Appendix G.

3.4.3 Environmentally Friendly Furniture

Though furniture likely doesn't have a negative effect on the environment once it has been manufactured, the standards that the company uses to manufacture and distribute their product can greatly affect the environment. In addition, how long the furniture can last without having to be replaced can affect a company's carbon footprint. For that reason, we contacted furniture suppliers across the globe and got an understanding of how sustainable their manufacturing processes are, their pricing, and their ideas for layout concepts so that we could recommend multiple supplier options for the CCCN to choose from. These companies were

identified with a few parameters to guide our search: a range of different styles, sustainable manufacturing processes if possible, and locally produced to CCCN if possible.

3.4.4 Environmentally Friendly Technology

Another design factor of a classroom that can impact the building's overall carbon footprint is the technology used. How technology is implemented contributes mainly to the electricity usage of the building. As stated above, electricity is the greatest contributor to the CCCN's annual carbon footprint, and most documents and classroom activities are digital and use technology in this pandemic world. In addition, CCCN is looking to make their new library very technologically driven, so that could increase the electricity usage of the building greatly. For that reason, we spoke with the executive director of the information technology department on the WPI campus. The goal of the interview was to get an understanding of how the WPI campus has worked to remain sustainable while consuming more energy as the campus integrates more technology. In addition, he provided us insight on measures to take that would support the internet requirements for research and gaming computers. The interview questions and protocol can be found in Appendix G.

3.5 Creating the Blueprints for Library Renovation

To provide CCCN with recommendations for the layout of their library renovation, we first looked at learning spaces in green certified buildings on the WPI campus for inspiration and

others across the globe. We took photos as well as notes on what seemed to work well to create spaces for collaborative as well as individual learning from a student's perspective.

Once we had determined what our team felt would work well for the renovation, we took these thoughts to faculty and staff at CCCN to share our thoughts with them as well as get their opinions as they will be the ones who use the realized space. We had informal conversations with the librarian, and with the executive, academic, and financial directors to get an idea of their opinions.

Next, we used the dimensions of the library and the features that we concluded from the interviews were essential for the renovation and used them to create multiple floorplans as well as 3D rendering of the space that we recommended for the CCCN to choose from. For our basic floor plan ideas, we used a free online software called Cedreo. We presented our four blueprint renderings to the academic team – ten members - at WPI and gave them a questionnaire to gather their opinions of each one. The survey questions can be found in Appendix I. Questions included getting their thoughts on what ideas they liked from each blueprint, what they didn't like, and what they feel they would like to see implemented that we had not already. We took all the responses into consideration when creating a final set of floor plan recommendations, which we could provide for furniture companies to implement their products into the spaces we have predetermined. From this, we could provide CCCN with a deliverable of several layout plan options showing them how they could take advantage of spaces. In addition, they would be able to see what the products from the furniture company they have available to them would look like in the space.

3.6 Methods Summary

The research we have done for CCCN had a few different goals that ultimately related in in how they could push CCCN along the path toward their final goal. We used the means of literature research, surveys, and interviews to complete our objectives. The following section, Results and Analysis, will outline the major outcomes of our methods.

Chapter 4: Results and Analysis

Our overarching goal was to aid CCCN on their way to a carbon neutrality certification which we could provide them with information on what governing body and certifications were available to them by means of research. Through research, interviews, and surveys, we were able to create several recommendations on floor plans for CCCN to choose from for the redesign of their library space. The goal of redesigning their library related well to their certification objective as we had to keep it in mind when deciding products to recommend for the outfitting of the modernized library space: Furniture, technology, and space sectioning.

4.1 Carbon Neutrality Certification

4.1.1 Application process

The CCCN had a good plan in place to manage Solid Waste well. Their waste reduction plan was sent to our group as part of their application for their certification. We have connected with a few offices that deal with carbon neutrality certifications. We also received a carbon footprint estimation from 2018 and 2019 from the CCCN which will be useful in the application process. We have information about their solar panel information and how they provide energy to neighboring buildings when they have extra power. All this information was culminated into a packet by the CCCN to present it to whichever certification they decided to apply for.

4.1.2 Carbon Neutral Country Program 2.0

The first one that we researched is the Carbon Neutral Country Program 2.0 which is a certifying body that was created by Climate Change Directorate (DCC) of the Ministry of Environment and Energy (MINAE). This Carbon Neutral Country Program 2.0 is one of the most prestigious and current certifications within Costa Rica. The DCC is located 1 block away from CCCN's San Pedro Campus which is advantageous when setting up meetings and requiring on site help with the certification process. Another advantage is that there are 5 distinct levels of carbon reduction certification so the CCCN can chose what degree of certification that they want. One disadvantage of this program is that there are no certifications for strictly facilities which makes it someone more complicated and we need to consider waste output.

4.1.3 *Institute of Technical Standards of Costa Rica*

The Institute of Technical Standards of Costa Rica (INTECO) is another government organized verifying body in Costa Rica located in San Pedro, San José and has certified 120 companies as carbon neutral in Costa. It has similar advantages to the Carbon Neutral Country Program 2.0 in terms of its location. Unfortunately, it only has one certification, and the institute has less resources for the carbon neutral certification, because they do so much more in terms of national technical standards, product certification, training, and education. This would mean that the CCCN would have less resources on hand to assist in the submission and approval of their application with this certification process.

4.2 Library Blueprints

We created four different blueprints that all had distinctive features, which can all be seen in the Appendix H. The four blueprints were presented to the academic team at CCCN along with a questionnaire to get their opinions and determine how we could incorporate the best aspects of each to recommend the final round of floorplan recommendations. The aspects that they liked from the different scenarios included:

- Option 4's gaming room setup was the closest to how a true esports tournament would set up their computers
- Option 1 & 2's incorporated open space concepts.
- Option 4's number of sliding walls that could both section spaces of when necessary but also open the space up when possible.

What they wanted to see included in future blueprints that had not been were:

- A better location or use of space for the ramp
- Multiple resource or help desks for the four librarians around the library so that they could each have a space for their belongings and look over different areas of the library
- Discard the office space for the head librarian as it's not necessary
- Find a way to effectively section off areas that will always be loud while keeping the rest as open as possible.

For the final blueprint recommendations, we had an extensive discussion with the librarian to go over the feedback from the academic team and try to implement everything they desired along with his requests. The first service they provide is the community and culture program, which includes the book club and readathon. They would need a silent room, a community meeting room and an intergenerational room, or lounge area, to house these activities. The second service would be career development. This includes the Esports area, toastmasters' program, and study groups. For these to be implemented in the library they would need group study spaces and a gaming room. Lastly, they want to create space for the limitless learning program. This includes the maker's space program and the storytelling area. For the library to host these it would need a media lab with research computers and a workshop for the maker's space. Since the space and budget for the library are limited, we had to be creative and determine how we could combine spaces and make different areas as multifunctional as possible. From that interview, we produced one of the final blueprints shown below in Figure 4.

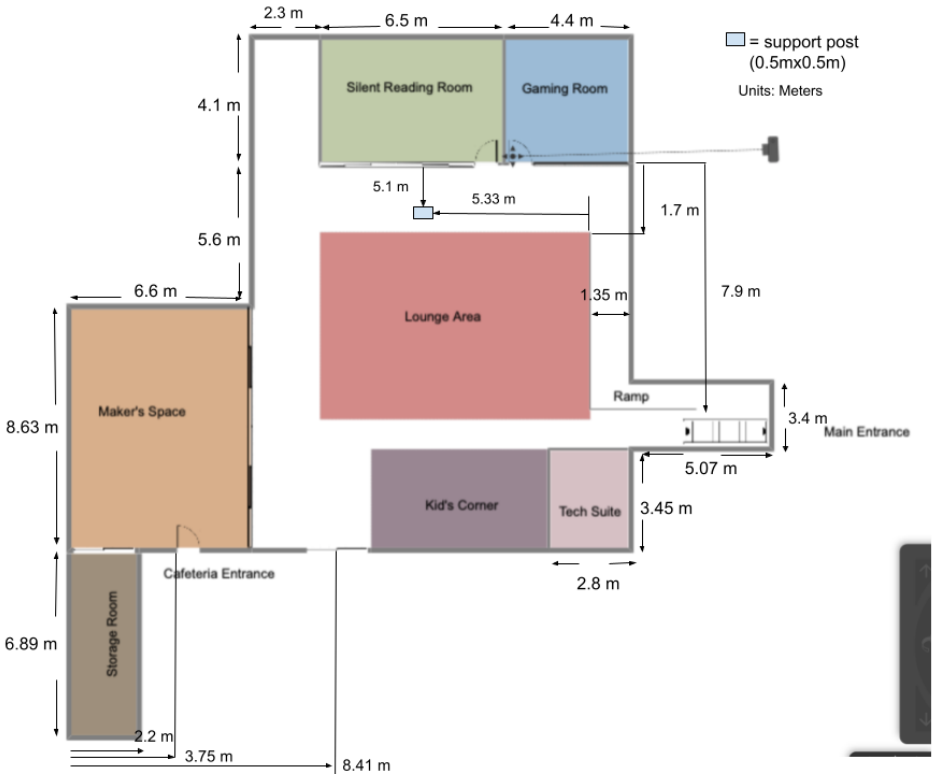

Figure 4: Final Floor Plan #1

As can be seen in the figure above, a lot of the details from our initial blueprints remain. As you enter the library through the main entrance, what originally was an office is converted into a tech suite for group work or meetings. Just a little further ahead, you can see the intergenerational room in the form of a kid's corner to your left and the general lounge area to the right. Past the lounge area to the right, there is the gaming room and the silent reading rooms. Straight ahead is the maker's space area that can be converted into a community meeting room for presentations. This blueprint was then sent to furniture companies such that they could recreate it while adding their twist of how they would arrange their products in the spaces.

After showing this initial final blueprint to a couple of the CCCN employees, there was still some feedback on things that could change. They decided that it would be best to provide them with 2-3 final blueprints, so they have multiple options to choose from. This took our path away from one single deliverable and more towards a couple options that they could combine into one. Figure 5 below is our second blueprint, that incorporates the academic director's feedback about trying to open the space as much as possible and moving away from the feel of a traditional library.

Figure 5: Final Floorplan #2

We moved away from having a secluded section for reading and let it be an open space that was only enclosed by a couch. This gives the design a much more open feel, also allowing the kid's corner to not be enclosed. The sponsor had also suggested that having a different space for research computers and gaming computers would allow them to be simultaneously used, which was incorporated into this blueprint. By only having the gaming room and the tech suite permanently closed off, this blueprint offers a very open concept design that can easily be shifted into one big open space as the sponsor desired.

In our third recommendation, we focused on the idea of a very open space with the option of sectioning off large areas using sliding walls which can be seen in Figure 6. This blueprint is also based around the concept of the main lounge area acting as a quiet space, while the loud spaces can be closed off to avoid disturbing the peace in the rest of the library. It also incorporates a different structure to the room, as the sliding walls are moved to the other side of the room. There would be a sliding wall between the maker's space and gaming room, as well as separating the two from the lounge area. This creates a longer and narrower lounge area compared to the relatively square one in the previous blueprint in Figure 5.

Figure 6: Final Floorplan #3

As you enter the library, there is a large lounge area that has a variety of furniture for different activities. This includes seating for young children, group story time, and individual work. When the noise level is at a minimum, the technology area and makerspace will be open to freely walk into, with no barriers in between. The technology room will be split into sections for research computers and gaming computers. The noise level of the gaming area should not be a concern to the research area since Esports events will not be a daily activity. The maker's space room will contain tables with plenty of storage to encourage hands on work in teams, as well as a

small open area for virtual reality. As these two rooms get loud, the sliding walls can close, keeping the noise from disturbing the quiet area.

4.3 Sliding Operational Walls

One of CCCN's major goals in the redesign of their library was the ability for the space to be opened up or converted into smaller spaces based on the day-to-day needs. They wanted to incorporate different sectioned office spaces into the library while still having the option to keep it as one big open room. To achieve this goal, we did research on different sliding operational walls that can be used to close or open a space depending on what the user wants. These walls would not only be useful for soundproofing but could also be used to block off light or visibility in certain sections. After viewing multiple wall options, our sponsor was interested in just the glass wall options. We narrowed the options down to 4 companies. CCCN has been provided with contacts and steps to continue getting information and quotes for these products, as seen in Appendix K.

4.3.1 Gaviota

The first company is Gaviota. It is a Costa Rica based company that has multiple different options for sliding partitions. The options we proposed for CCCN's library are the Nuda, Serie Plegable 6400 and the Tomei. These options are all glass walls with very minimal framing that can open and provide an expanded feel to the library. They can be up to 10 mm

thick and can offer full soundproofing when closed. They can be opened slightly to provide access to the room even when closed, giving it the feel of a door. We have connected them with CCCN as they would like to visit the library space to determine the exact dimensions and specifications that would be needed to provide a quote.

4.3.2 Bella Vida

A second company providing glass walls is Bella Vida. This company is locally based in Costa Rica and has multiple different suppliers. They are more of a middleman for the manufacturers, and they could come and install the wall that CCCN chooses. These walls can be up to 25 mm thick and would provide good soundproofing for the library. The main manufacturer that would service CCCN's needs best would be LaCantina Doors, which provide folding glass doors. The only downside to these doors is that they have thick metal framing, which wouldn't have the same open feeling that other companies' walls provide.

4.3.3 Hawa Solutions

A third company was Hawa Solutions. The first benefit of this company is that they have a manufacturer in Costa Rica through AICSA. This would make it very easy for CCCN to obtain this company's wall without the need for freight to be shipped from the United States, for example. The specific product is the Hawa Centerfold 80 which is a glass sliding wall that is fully mounted and electrically operable. It provides soundproofing since it will run floor to ceiling, but it will not completely block off a room due to the glass panels. Another distinct advantage to this wall type is that one of the panels can include a door. This would make for easy

access in and out of the room when the wall is closed. The company provided us with a PDF that has multiple different specifications for the wall, including the motor, the thickness of the wall, what kind of slider, etc. This was forwarded to CCCN as it would be their choice what specifications to get. From this they would be able to get a cost estimate.

4.3.4 Crystalia Glass

Another excellent option for a sliding glass wall is the SGL-116 from Crystalia Glass, a United States based company. This wall features sliding glass panels with several minimal frames that would allow the wall to completely open to just the size of one frame, and therefore, open up the space. The glass comes in either 3/8” or 1/2” thicknesses and is fully tempered glass. When it is closed, there is the option of only opening one panel which could be used as a doorway. A benefit of this option is that it offered a sleek modern look that would fit the style of the overall renovation of the San Pedro campus. When contacted, the company said there are two options for purchasing. One is that CCCN could buy the entire set including the hardware and the glass and have it shipped internationally. This option would cost US $19,995. The second option is to buy just the hardware and buy the glass locally. This option would cost $9,995 for the just the hardware.

4.4 Gaming Technology

One space that CCCN is looking to include in the library is a gaming area. The primary uses for this space would be Esports events and casual gaming. They would need five to seven complete gaming setups for this space. A gaming setup includes a computer, keyboard, mouse, monitor, desk, and chair. One of the main factors we considered when researching these products was the cost. Purchasing all the necessary components for a gaming setup can become expensive when implementing high quality products. Another factor that we considered was the energy efficiency of the units, since CCCN is looking to acquire a carbon neutral certification in the near future. Here are the options that we decided were best for CCCN considering those factors.

4.4.1 Sponsorship

One possible method of supplying the products for the gaming space could be sponsorship. Many colleges and professional Esports venues use these sponsorships to affordably purchase many products. In return, these companies receive brand recognition from the advertisements they post around the venue. This could be the perfect opportunity for CCCN to affordably supply gaming computers and equipment, while a gaming company could increase their brand recognition in Costa Rica.

One company that we reached out to was iBuyPower, one of the largest gaming companies in Esports. They informed us that their sponsorship program was currently suspended due to the COVID-19 pandemic; however, they would still investigate this possible sponsorship despite the circumstances.

4.4.2 Individual Components

The next best option after sponsorship would be to order the components individually. CCCN has informed us that they are able to purchase products from Amazon, which allows us to purchase products like gaming supplies from retailers outside of Costa Rica.

For the computer, the Acer Predator Orion 3000 P03-630-UA15 Gaming Desktop is a great option. This computer is powerful enough for any game that is currently available, given that it has a GeForce RTX 3070 graphics card. It is also an Acer product, which is one of the most well-known brands in gaming. This product also comes with the Predator Gaming RGB Keyboard and Mouse. This will allow CCCN to get the most for their money, so that they can fit the products into their budget. This is especially important when you consider that they will be purchasing five to seven gaming computers. This product also ships to Costa Rica, which is especially important because a handful of large gaming companies do not ship their products to Costa Rica, even with Amazon. The product, which includes the computer, keyboard, and mouse, is currently priced at $1700 before shipping.

The ASUS VP249QGR Gaming Monitor is a great option for the monitor. It has a resolution of 1080p and a frame rate of 144 hertz, which are the standard for Esports. It is also made by Asus, which is another top name in the gaming industry. This monitor also has Extreme Low Motion Blue Sync Eye Care, which is better for the human eye than most gaming monitors. This is important because most of the people using the Esports area will be kids to young adults.

This monitor is currently $190 on Amazon, with shipping to Costa Rica available.

4.5 Learning Technology

To foster a more interactive learning experience, CCCN is looking to get desks with an integrated touchscreen. They are hoping that with these touchscreens, students can read e-books like reading a real book and learn through interactive games or lessons.

The best company that we found for these touchscreen desks is Pro Display. They are based in the United Kingdom and have a wide array of products that utilize touchscreen displays in different scenarios. Their touchscreen desks come in an array of sizes ranging from 22” to 55”. The smaller models are more effective for reading books, as they are closer to the same size as a book. On the other hand, the larger models are superior for interactive games and lessons. These models could also be used by multiple people at once for a collaborative experience. The 22” model has a price point of around $3700, while the 55” model is roughly $7000. Shipping would cost an additional $900 with Ocean Freight shipping, which is the preferred international shipping company of Pro Display.

Another option for touchscreen desks is a custom-made alternative from the companies who are already furnishing the library. When CCCN decides on a furniture company, they can inquire about having holes cut into the desks where a tablet can be installed securely. This option would be more cost effective, as they will be utilizing a company that is already completing work for

them. There will be no extra shipping costs associated with the touchscreen desks, which would cut the overall cost significantly.

CCCN is also looking to purchase virtual reality headsets as a part of their interest in creating a more interactive learning experience for their students. As with most parts of the remodeled library, they are looking to make this experience very mobile. They should be able to pull the headsets out of a storage area when they are needed and put them back with ease. Because of this, the best option is to select standalone headsets, which do not require any connection to a computer or external tracking sensors. We have found two great options that meet these criteria.

The first option is the Oculus Quest 2 by Facebook. The biggest advantage of this headset is that it is a powerful headset for a low price. At currently $300, this headset is one of the cheapest virtual reality headsets while being very powerful. This is an important factor for CCCN due to the number of teenage kids who will be using them, leading to a higher chance of them eventually breaking. These headsets are also very mobile and relatively small for a virtual reality headset. There is also a version that includes 256 GB of storage compared to the standard 128 GB for $400 if CCCN plans on purchasing a wide variety of content.

The next option is the HTC Vive Focus 3. This headset is like the Oculus Quest 2 in the sense that it does not require a computer and it is relatively small. The two main differences are that the Focus 3 is more powerful and expensive. At $1300 currently, this headset is over 4 times as expensive as the Oculus Quest 2. This would be a better option for CCCN if they want to play

very graphic intensive games. Otherwise, it would most likely not be a good decision to choose this for financial reasons. CCCN could also choose to purchase some of each product in order to have headsets for general use as well as headsets for high graphic content.

4.6 Sustainable furniture

A major goal of the center is to keep their carbon footprint to a minimum wherever possible. For that reason, we conducted research to find furniture suppliers that used sustainable manufacturing processes. In addition, we wanted to provide the center with a range of prices and styles such that they could get a feel for all their options. Several things would contribute to the pricing including the quality of the furniture and whether it must be imported or not. We also attempted to provide as many locally made options as possible from our research but struggled with that pursuit. The following section describes each of the final furniture manufacturers we presented to CCCN with their benefits and drawbacks. Lastly, contacts from each of the suppliers were provided to CCCN so that communication could continue seamlessly with whichever company they choose to continue with.

4.6.1 VS America

VS America is a manufacturer based out of the United States, but they can provide international shipping. They also would not require a freight forwarder once the product reached the Costa Rican border as they have experience in projects across the globe. VS America makes a very modern and simplistic style of furniture from metals and plastics as shown in Figure 4.

Figure 7: VS America Library

They have a few certifications that verify sustainable manufacturing processes including Quality Management System DIN EN ISO 9001, ISO 14001, 50001, and a Chain of Custody PEFC D 1003. Additionally, they have wood combustion facilities, and fully recycle their steel. VS America would be a good option for the areas that require powering for technology as they are able to embed inserts in their tables to supply it. A very interesting feature that VS America was able to create for the space was a "learning staircase" where students of practically any weight could sit and read or the younger students could climb on and play which can be seen in Appendix I. This feature would make the space feel modern, fun for all ages, and be relevant for many years. While VS America has an impressive portfolio, they are not local to Central America, so that makes it a relatively expensive option and it doesn't promote locally made products. Also, they do not tend to do custom work unless it is ordered in bulk. Many of the CCCN employees liked this option and the modern yet unique style it provided. Sample

renderings of what VS America could do with the library space are provided in Appendix I. It is worth noting that the renderings shown in this appendix are what the designers at VS America felt would be the best way to incorporate their products into the space, but they are happy to adjust what products they use as they have many alternatives at different price ranges to satisfy any customer's needs. The quote for the renderings in Appendix I is $164,966.63.

4.6.2 Natural Pod

Natural Pod is a British Columbia, Canada, based company that creates mainly wood based furniture. They aim to create a simplistic and natural style. They are known for making spaces for a younger demographic of students. They use quality nontoxic woods from trees harvested using Forest Stewardship Council® certified source materials. This means that they are certified under Sustainable Northwest's FSC® Chain of Custody Group (C012237). They are also very capable of doing custom work for clients with enough lead time. What doesn't make Natural Pod the best option is that it is not a Costa Rican based company, and they do not make furniture that appears very comfortable, especially for the younger students at CCCN as depicted in Figure 5.

Figure 7: Natural Pod Furniture

Although the CCCN employees liked this option, they were worried about the degree of comfort of the benches and the wooden style.

Sample renderings of what Natural Pod could do with the provided library space can be found in Appendix J. Along with the renderings, they provided an estimate of $77,682.84, including the price of importation. However, it is worth noting that this price is only based on the furniture that they included in their sample rendering, and CCCN has the option to only purchase as much of the furniture as they choose. For example, Natural Pod is prototyping a new bleacher feature that would work well in the kid's corner of the library, and they would be happy to only supply this to CCCN if they chose to go with another company for the remainder of the furniture as they believe their products for kid's spaces outshine those of any of their competitors.

4.6.3 AFD

The third and final furniture company that we contacted was AFD. AFD is a furniture supplier based out of the United States that supplies numerous manufacturers that do a range of styles of product including Steelcase and Smith System – two manufacturers that create product tailored toward a school setting. The benefit of AFD being a supplier rather than a sole manufacturer is that they can provide CCCN with a wide range of different product styles all from one place. Similar to VS America, the two manufacturers listed above, create a modern, and sleek look with metals and plastics which is depicted in Figure 6.

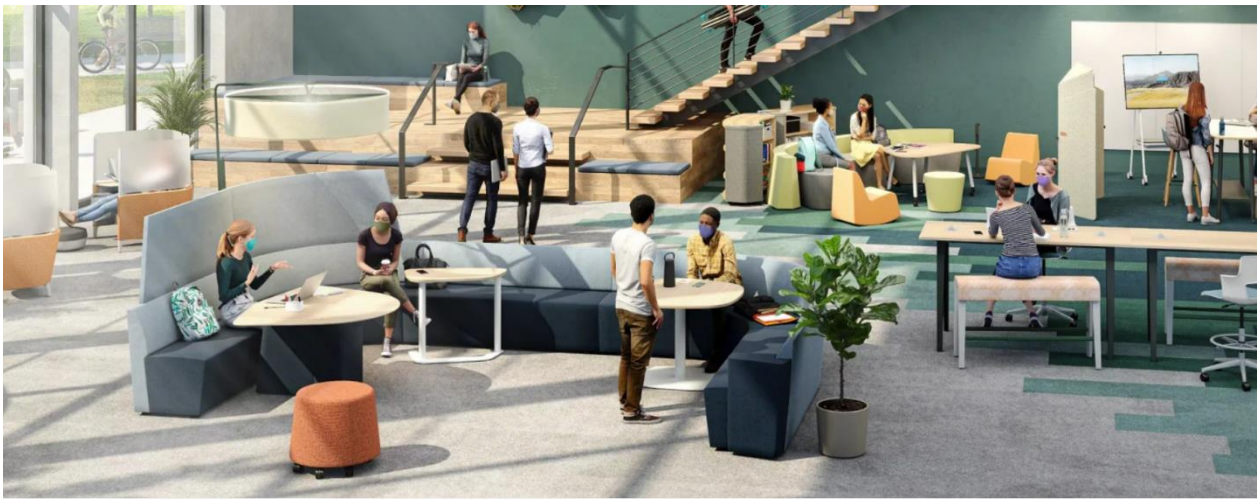

Figure 8: Steelcase Furniture

Another benefit to AFD is that they have a sales office and show room in San Jose, Costa Rica, therefore, allowing for CCCN to see some of the products they may be interested in purchasing in person beforehand. While there are numerous benefits to AFD, there are two distinct setbacks: They are based out of the United States to there will be a cost to import the products, and they do not tote any of the sustainable manufacturing certifications that the other two options

do. The sample renderings from AFD can be found in Appendix K. They were not able to supply us with an estimate to go along with the renderings.

Chapter 5: Conclusions and Recommendations

We were able to provide CCCN with several options for the layout of their library redesign as well as furniture, technology, and movable walls such that they would feel they could make an informed decision based on all the options available to them. From our research, they should be able to create an interactive, flexible, and user-friendly library space that will withstand the test of time. In addition, this space should not retract from CCCN's ability to reach carbon neutrality certification from a local and reputable certifying body. In this chapter we provide some final suggestions and recommendations about how CCCN could continue towards their carbon neutrality certification goal along with their library redesign project.

5.1 Carbon Footprint

Based on the documents that the CCCN gave us on their carbon footprint estimation, waste management, and solar panel information we decided that the Carbon Neutral Program 2.0 would be the best fit. The Climate Change Directorate's office, which oversees this program, is located close to the CCCN's San Pedro Campus which makes it logistically easy to meet up to discuss certification requirements. In addition, there are two different levels of carbon neutrality certification that the Center can choose between based off how much work they are willing to put in for the certification process. This process will take them a few months which is relatively short and can be easily revised when the Center undergoes their major renovation in about a year.

5.2 Library Blueprints

The final blueprint that we chose as the best option is seen below in Figure 5.

Figure 9: Final Floorplan #2

We chose this option because it provides multiple different spaces that can be combined into one large open space. The maker's space is closed off by a sliding glass wall that gives it an open feel, as CCCN had wished for. When not in use, the maker's space materials can be stored away

in the storage room, the glass wall can be retracted, and chairs can be brought in for a medium sized presentation. The kid's corner also provides a sectioned off area for CCCN's younger students which is important to make them feel comfortable and allow them to have a space away from the adult users. The silent reading area provides a relaxed corner for those who want a quieter space that incorporates a reading staircase that CCCN was very excited about. However, the silent area is still open to the general room to maintain the open feel. The gaming room is in an ideal spot due to its closed off nature because gaming can get very loud. The open space in the middle of the room allows for CCCN to do with it as they please whether it be a lounge area with couches, tables for work, or a mix. Lastly, the research area is accessible and visible to all which encourages students to use its computers. With all these aspects combined into one blueprint, we believe it would be the best way to use the space, leaving it open but still having the option to close sections off that require that ability.

5.3 Sliding Operational Walls

After a lot of research, we were able to provide the CCCN with 4 glass sliding wall options. Since they were more interested in local companies to reduce shipping costs, three out of the four recommendations were companies that have a manufacturer or are based in Costa Rica. Among these 4 options, the company that we recommend is the HAWA Centerfold 80. We think this would be an excellent option because the panels are motorized, meaning it would make it very easy to open up the space quickly. It is also a rather affordable product because it has a

manufacturer in Costa Rica called AICSA, which would allow the shipping cost to be decreased. Another advantage to the Centerfold 80 is that a door can be installed into one of the panels. This gives it a unique advantage in that students could easily access the makerspace even when the wall is closed.

5.4 Gaming Technology

We were able to provide CCCN with two recommendations for acquiring gaming equipment. Those recommendations are an Esports sponsorship or a suggested list of individual gaming components. An Esports sponsorship from iBuyPower is the ideal option due to its financial advantage over buying large amounts of gaming equipment. Because of the uncertainty of this sponsorship, we also identified the best gaming products for CCCN to purchase individually, based on cost and energy efficiency. This would help CCCN achieve its carbon neutral certification.

5.5 Learning Technology

We also identified devices for interactive learning, specifically virtual reality headsets and touchscreen tables. CCCN wanted virtual reality headsets that could easily be stored and brought out during designated play times. Because of this, we recommended two headsets that have high portability because they do not need to be connected to a computer. The Oculus Quest 2 has

excellent value and is powerful enough to play most games, which is why it is the optimal choice between the two. In the event CCCN wants to play immensely powerful games, the HTC Vive Focus 3 would then become a better choice. For touchscreen tables, Pro Display offers many different sizes of tables from 22” to 55”. The major downside of these tables is their high prices along with the need for international shipping. Another option is to request a custom touchscreen desk from the furniture company they use for outfitting the rest of the library.

5.6 Sustainable furniture

We recommend that CCCN chooses to get their furniture supplied from VS America. The first, and likely most weighted, reason being they create modern and comfortable products that really seemed to excite the CCCN directors as well as go along well with the vibe of the overall building renovations that will be happening soon. Second, they can supply products that satisfy many of CCCN’s needs: Cool features for kid’s play area, furniture that can support the powering of technology, and products that have options to move or store them away easily to create flexible spaces. Finally, VS America has a few certifications verifying that they use sustainable manufacturing processes to create their products. This is an added benefit, considering that CCCN themselves is attempting to achieve similar certifications and minimize their own carbon footprint.

5.7 Conclusion

From these recommendations, we hope that CCCN can complete the requirements necessary to receive the Carbon Neutral Program 2.0 Certification that would assure they are a carbon neutral facility and remain vigilant of their footprint. In addition, we hope that our recommendations for the library renovation provide creative ideas as to how they can arrange the spaces. Finally, we hope that our purchasing recommendations to outfit the library allow them to make decisions with all the knowledge necessary to understand the options available to them based on their needs. All of this is to say that our work hopefully can be the foundation for the redesign of a library that will be inviting, comfortable, and a memorable experience for any visitor at CCCN.

Further research that could be conducted would be to see if there are any local furniture suppliers that would meet CCCN's needs as we were not able to locate any online of the caliber we were looking for. Also, it would be interesting to see if there are any local artisans that could custom make the inserts for tablets in tables as an alternative to Pro Display at a cheaper price point.

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Appendix A: El Centro Cultural Costarricense Norteamericano

El Centro Cultural Costarricense Norteamericano (CCCN) is a non-profit center based out of San Pedro, Costa Rica. According to their website (Centro Cultural Costarricense-Norteamericano, 2021), it was founded in 1945 with the goal of creating educational programs for the less privileged people in the area that established a link between Costa Rica and the United States. The programs they put on include, but aren't limited to, book donations as well as English and cultural courses. They pride themselves on being premier teachers of the English language as well as the cultures of Costa Rica and the United States. Currently, the center employs 186 people and has 5,100 students. Whether through day-to-day practices such as electricity, transportation, and water usage, or indirectly through the purchase and usage of goods at their facilities, a large organization such as the CCCN has the potential to have a negative impact on the environment.

Appendix B: ISO Certifications

International Organization for Standardization (ISO) is a non-governmental organization that brings experts together to provide solutions to global challenges (International Organization for Standardization, n.d.). They develop international standards such as ISO 9001 and ISO 14001, but they are not involved in the process of issuing these certificates. ISO 9001 is a quality management certification for organizations that are looking to improve the quality of their products and consistently meet their customers' expectations. ISO provides organizations with a set of quality management principles to follow to achieve this certification. ISO 14001 is an environmental management certification that allows organizations to set up an effective environmental management system. It may be used to reassure stakeholders and employees that the organization's environmental impact is being measured and improved. Most of the criteria for an ISO 14001 certification focus on improving and maintaining the environmental impact of the organization (United States Environmental Protection Agency, n.d.). Some of these criteria are setting performance targets, implementing the environmental management system (EMS) to meet these targets, periodically auditing the EMS, taking preventative actions when deviations occur from the EMS, and taking periodical reviews by management.

Appendix C: Carbon Neutral Building Design Expert Interview Questions

Hello, my name is Michael Nason. My name is Loren DiLoreto. My name is Luke Reid. My name is Francesco Valagussa, and we are a group of WPI Students doing a project to help the CCCN decrease their carbon footprint. As a reminder, this interview can be anonymous, and your identity will not be tied to any answers that you give unless you express consent that we can use your name. Your answers will only be used to help analyze how we can design a building, specifically the classrooms, to emit the least amount of carbon emissions as possible. Here is a card with the email address that you can reach our group at as well as WPI's Global Projects Program in case you have any questions after we have finished.

- We can conduct this interview in English or Spanish; which language would you prefer us to use?

- Can we record this interview so we can review the responses at a later date as well as quote you in our proposal, if you give us permission to do so?

-How long have you worked as a _____?

- What is your experience in the overall design process of buildings and rooms trying to be "carbon neutral" or environmentally friendly?

- Have you worked on any buildings that are ISO 14001 Carbon Neutral Certified or any similar certification? If yes, please tell us about these buildings and how they were designed.

-We noticed that several WPI buildings are LEED certified. Can you talk about this?

-How does a building go about acquiring a carbon neutral or environmentally conscious certification?

- What style of light fixtures were used in the building? Did they include any features such as motion sensing timers? Why or why not?

-What sort of furniture was purchased or do you know of companies that produce environmentally friendly furniture (e.g. use recycled materials)?

-How can technology be implemented to reduce the electricity usage in a building? An example of this could be energy efficient outlets. Can you give us some examples of such buildings at WPI, in San José or Costa Rica?

-Was water usage something that you focused on as well? For example, did bathrooms have motion sensors on sinks or toilets that use less water when possible? Please explain why or why not.

-Is there anyone else that you could refer us to for further insight into this topic?

Appendix D: PAS Certifications

PAS certifications are carbon neutrality certifications developed by the British Standards Institution (EcoAct, n.d.). The two main certifications are PAS 2050 and PAS 2060. PAS 2050 focuses on identifying, understanding, and reducing emissions. PAS 2060 builds on PAS 2050 and focuses on reducing net emissions entirely. In order to obtain a PAS 2060 certification, an organization must have net zero emissions. This is determined through audits, which are performed by third party contractors. The PAS 2060 is mostly used in the European Union; however, organizations from all over the world are starting to use it because of its international credibility.

Appendix E: CCCN questionnaire for Giovanni Sanchez

1. What supplies is CCCN currently purchasing for their students or faculty?
    a. What suppliers are they purchased from?
2. What is an approximate budget for the desks in the library?
    a. What else will need to be purchased for the library.
3. Are there any materials that will start to be purchased within the next year?

Appendix F: Questionnaire for Head Librarian

1. Is there any specific study space you would like to be implemented in the new library?
2. Do you favor group spaces or private work spaces?
3. What is the typical atmosphere like? (loud, quite, laid back)
4. What furniture is being kept and what needs to be replaced?
5. Is there anything the current library doesn't have that you believe would be useful after the remodeling?
6. How many students tend to be in the library at a time?

Appendix G: Library Floor Plan Questionnaire

Vamos a presentarles cuatro ideas diferentes enseñando como podemos organizar los espacios diferentes para la renovación de la biblioteca. Después de cada presentación, vamos a darles tiempo para escribir sus opiniones del espacio en el Google Form.

1) What did you like the most about blueprint #1 / Qué te gusto de plano #1?

2) What did you not like about the plan, if anything? What would you change? / ¿Qué no te gusto, si hay algo, sobre cianotipo? ¿Qué cambiarias sobre el plano?

3) What did you like the most about blueprint #2 / Qué te gusto de plano #2?

4) What did you not like about the plan, if anything? What would you change? / ¿Qué no te gusto, si hay algo, sobre cianotipo? ¿Qué cambiarias sobre el plano?

5) What did you like the most about blueprint #3 / Qué te gusto de plano #3?

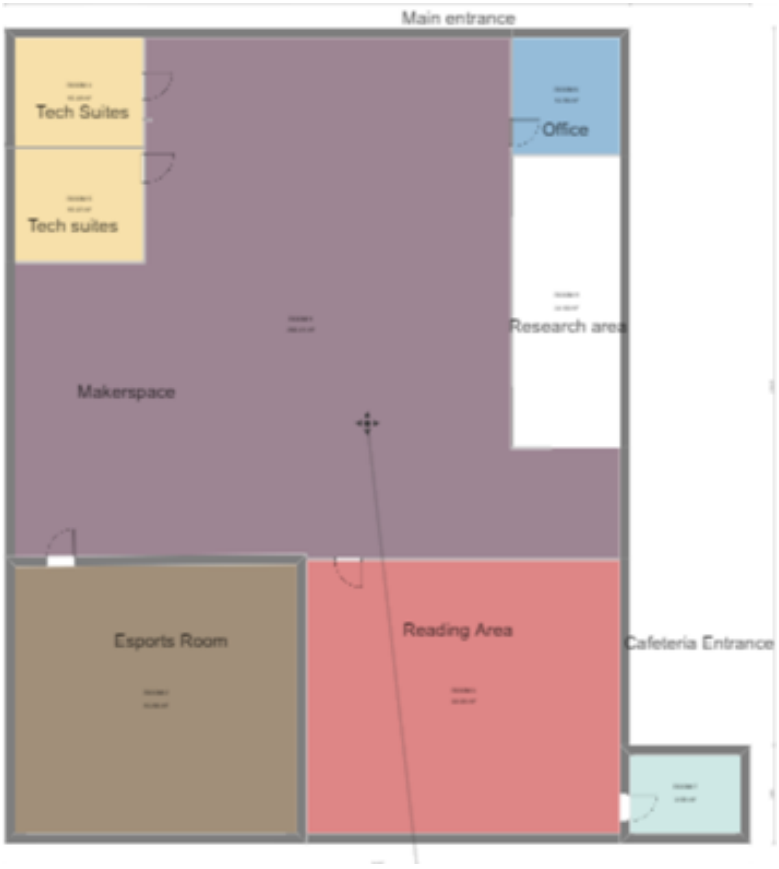
6) What did you not like about the plan, if anything? What would you change? / ¿Qué no te gusto, si hay algo, sobre cianotipo? ¿Qué cambiarias sobre el plano?

7) What did you like the most about blueprint #4 / Qué te gusto de plano #4?

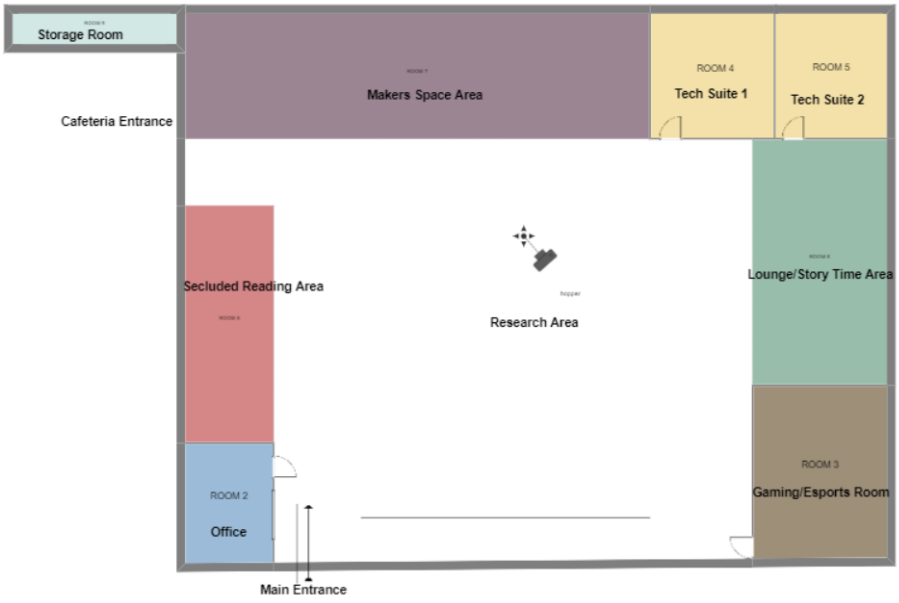
8) What did you not like about the plan, if anything? What would you change? / ¿Qué no te gusto, si hay algo, sobre cianotipo? ¿Qué cambiarias sobre el plano?

9) Do you have any other thoughts or opinions that you would like to see included in the final plans? / ¿Tiene algún otro pensamiento u opinión que le gustaría ver incluido en los planes finales?

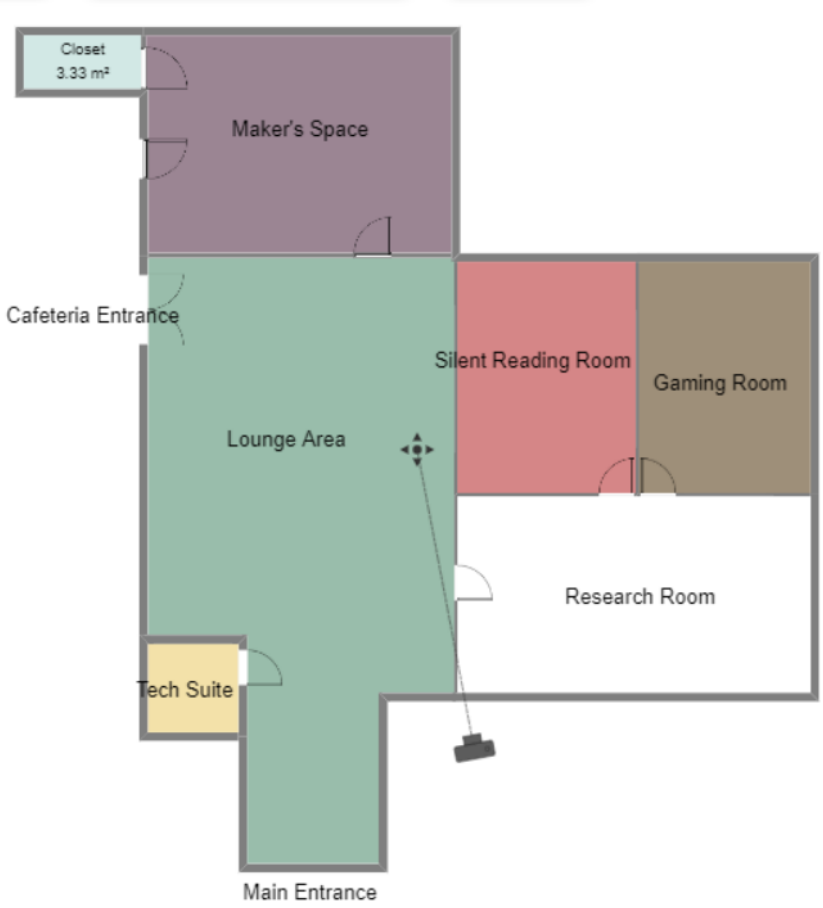
Appendix H: Initial blueprint designs



Option 1


Storage Room
Cafeteria Entrance
Makers Space Area
ROOM 4
Tech Suite 1
ROOM 5
Tech Suite 2
Secluded Reading Area
Research Area
Lounge/Story Time Area
ROOM 2
Office
ROOM 3
Gaming/Esports Room
Main Entrance

Option 2


Closet
3.33 m²
Maker's Space
Cafeteria Entrance
Silent Reading Room
Gaming Room
Lounge Area
Research Room
Tech Suite
Main Entrance

Option 3

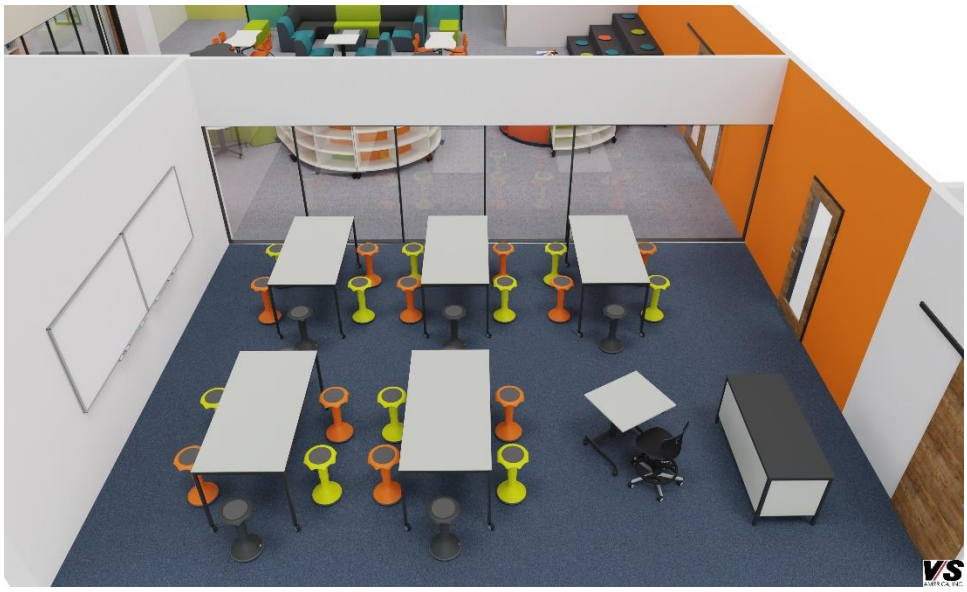

Tech Suite 1
Tech Suite 2
Reading/Storytelling
Gaming/Esports
Makerspace
Research/Social Area
Storage Room

Option 4

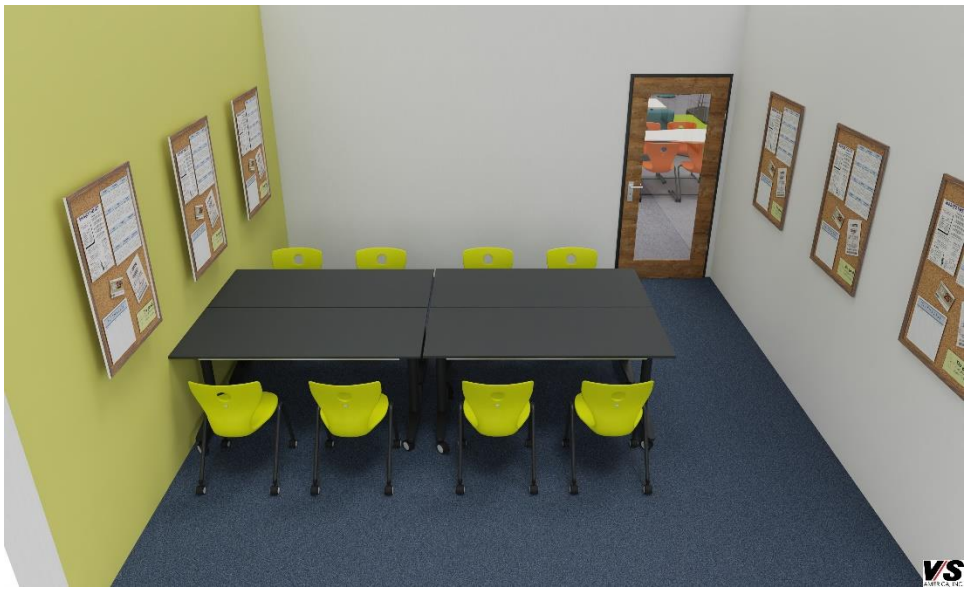
Appendix I: VS America Sample Renderings

Overall Floorplan

Lounge Area and Kid's Corner



Maker's Space



Tech Suite

Kid’s Corner

Silent Reading Room

Appendix J: Natural Pod Sample Renderings

Floor Plan

Lounge Area

Maker's Space

Silent Reading Area

Tech Suite

Kid's Corner

Appendix K: AFD Sample Renderings

Lounge Area View 1

Kid's Corner

Lounge Area View 2

Maker’s Space View 1

Kid’s Corner View 2

Lounge Area View 3

Gaming Room

Research/Silent Reading Area View 1

Research/Silent Reading Area View 2

Appendix L: Sliding Walls Follow up action for CCCN

HAWA Contact: Huber, Andy andy.huber@hawa.com

He has provided a PDF with all the specifications needed in each sliding wall. Once this is filled out it can be sent back to HAWA and they will provide CCCN with a cost estimate for the project.

Bella Vida Contact: They can be contacted through https://bellavidacostarica.com/contact-us/ and will give CCCN multiple options that could satisfy their need for the project

Gaviota Contact: Wong Chang, Miguel m.wong@gaviotagroup.com

They have provided 3 different presentations, one for each of their opening glass partitions. These include the specifications for each product and pictures of it in use. These have been sent to CCCN to view. They have offered to come in and see the space in an attempt to get a proper estimate for the product and provide CCCN with a quote.

Crystalia Glass Contact: Mikhailenko, Denis den@crystaliaglass.com

They have provided two options for purchasing, including the quote for each one. These have been sent to CCCN and they will assess whether to continue with this option if they are interested.

Appendix M: Furniture Company Contacts

Natural Pod: Rosensweet, Kelly krosensweet@naturalpod.com

VS America: Lowes, Andrew a.lowes@vsamerica.com

AFD: Lahmann, Irene ilahmann@iwe-inc.com

Appendix N: Certification Body Contacts

DCC: cambioclimatico@minae.go.cr

INTECO: certificaciones@inteco.org