EEL 4911C/4915C, EML4551C/4552C

Electrical and Computer Senior Design, Mechanical Engineering Senior Design

Team 505: Pop-Up Classroom

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Abstract

The Pop-Up Classroom (PUC) is a device that focuses on combining a typical classroom environment with tools for collaboration on a mobile platform. The device is based on a previous senior design project but incorporates a new mode of control and various media devices. Tests for the device were designed to ensure the product met specified targets and metrics, though not all tests were able to be completed due to external circumstances. Physical and simulated tests of the device provided insight into ways to improve, such as adding additional support beams to the roofing component. Code function was simulated through alternative methods, such as the lighting of LED lights and the use of outputting orientation to screen. Once environmental restrictions are lifted, there are tests outlined to conduct missing experiments from the previous section and user experience in general. The final product was found to fulfill the requirements set forth and provides a new learning experience for users.

Commented [1]: From Conference Paper

Keywords: Mobile Learning, Collaboration, Campus Vehicles, Alternative Teaching, Autonomous Vehicles, Accessibility, Connectivity

Disclaimer

The parties that worked on the product assume no responsibility in the case that the final product causes harm, injures, or fatally hurts its users. The project developed here was done with the purpose of putting in practice what the students had learned so far in their college experience. For further instructions regarding proper care and usage, please refer to Appendices D and G. Use at your own risk.

Acknowledgment

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Notation

3D	Three-Dimension
AV	Audiovisual
BOM	Bill of Materials
bps	Bits per Second
CAD	Computer-Aided Design
COE	College of Engineering
CRI	Campus Reimagined
EE	Electrical Engineering
FAQ	Frequently Asked Questions
FEA	Finite Element Analysis
GPS	Global Positioning System
Hz	Hertz
IEEE	Institute of Electrical and Electronic Engineers
kWh	Kilowatt per Hour
lb	pound
LED	Light Emitting Diode
ME	Mechanical Engineering
PUC	Pop-Up Classroom
TBD	To Be Determined
W	Watts

Chapter One: EEL 4511/EMC4551

1.1 Project Scope

1.1.1 Project Brief

Campus Reimagined (CRI) seeks to create a new campus experience through a PUC. The popup classroom should provide a collaborative environment that is nomadic and has the capability of being ordered online. This device will enable a comfortable interaction between professors and students, faculty, and classmates. It will include all the necessary things so that lectures, meetings, and conversations are pleasant.

1.1.2 Project Description

The purpose of this project is to design a nomadic classroom that can accommodate the key components of a learning environment. It should allow for educational instruction outside of the standard classroom setting. The project includes a website at which users can book the PUC for a chosen time and location.

1.1.3 Stakeholders

The PUC project has implications for the future of educational and collaborative setting. Stakeholders have been identified for this project in relation to its potential applications. These stakeholders fall into four main groups: sponsors, advisors, agencies, and impacted customers. Note that this list is not all inclusive.

The sponsors category includes members that have a monetary interest in the project currently. This category includes Campus Re-Imagined and the FAMU - FSU College of Engineering.

The advisor’s category includes educational and engineering mentors for the project and includes Dr. Shayne McConomy and Dr. Jerris Hooker. Dr. McConomy serves as the faculty advisor for the project while Dr. Hooker serves as the instructor of half of the team’s senior design class.

Agencies that may have an interest in the project include the State University System of Florida, disaster relief agencies, and the military. The State University System of Florida provides university regulations and the approval of the popup classroom design may implement new legislation to increase the range of educational opportunities. Disaster relief agencies can utilize the product when serving communities that have been devastated by natural disasters, particularly around education institutions. All military branches may benefit from the success of this product to increase the comfort of meeting points and the portability of important facilities during deployment.

Impacted customers include people who may be affected by the product’s release and implementation. The main two sectors would be university students and parents and public figures. University students and parents will be affected as the product would have an impact on the educational experience and the students’ capabilities to obtain knowledge. Public figures may wish to utilize the device for impromptu meetings and provide a comfortable area for questioning after major events.

This product has many stakeholders, with the sponsors and advisors being currently affected and invested in the project. The educational and presentational implications of the project description allow for this list to adjusted and added to as it progresses.

1.1.4 Market

The markets for this device have been identified based upon its current purpose. The primary market are educational institutions. This is due to design’s purpose currently being focused on creating a learning environment. Secondary markets have been identified based upon the collaboration aspect of the project. The secondary market includes student organizations and clubs, the government for military use, and disaster relief organizations. These markets will be taken into consideration during the design process, with educational institution attendees being the target customer regarding customer needs.

1.1.5 Key Goals

This project's focus is on mobility, user experience, and energy optimization. The following key goals were found to satisfy the project description.

- The device is transportable.
- The device has wireless connectivity capabilities.
- The device's moving parts require average strength to maneuver.
- The infrastructure for the classroom is centered on promoting a collaborative group experience.
- The device is user friendly with minimal trouble-shooting time.
- The device should be able to power itself.
- The device is integrated with an online platform.
- The device provides shelter for users from environmental factors.
- The device accommodates 10 - 15 participants.

Additional key goals may be added as customer needs are identified.

1.1.6 Assumptions

The following assumptions will be utilized to assist in governing the project direction.

1. The product will be based on a small multi-terrain vehicle.
2. A nomadic prototype is expected by the completion of the project.

3. The product will be built for outside usage.
4. The product will not include autonomous capabilities in the first iteration.

These assumptions will assist in determining the project timeline and design selection.

1.2 Customer Needs

This project is defined by the interactions of customers with the product and how it may be integrated into the educational setting. The team conducted interviews with the sponsor, students, and educational staff to determine the needs of those it will be serving. The following table lists the questions asked specifically to the sponsor and those asked to the interviewed persons, as well as the interpreted need defined by the group. Note that the information provided within the questions to general customers represents a summary of multiple inputs.

Table 1 *Customer Survey Information*

Question/Prompt	Customer Statement	Interpreted Need
Questions to the Sponsor		
As Stated in Project Brief	The popup classroom should provide a collaborative environment that is nomadic and has the capability of being ordered online	1. The layout provides the ability for collaborative input
		2. The product is mobile
		3. The product is integrated with an online platform
What is the required terrain?	Surfaces around campus or in parks	4. The device can maneuver common university terrain
What was the need that prompted this project?	Enabling conversations and valid discussions whenever it is wanted	5. The device is easily accessible to the customers
What is your opinion of the standard classroom setting?	The standard classroom setting is not conducive for critical thinking and creative learning.	6. The device promotes creativity and interactive learning

How many people will be using the device at one time?	From the size of small project groups to the size of group studies or tutoring	7. The device accommodates 10 to 15 people comfortably
What level of mobility is being asked for?	It should be nomadic with off-road preferred, can be driven or pulled initially with autonomous capabilities not being present in the first iteration	8. The device's motion can be manual, with powered or autonomous motion being implemented in later versions
		9. The device can be packed to reduce the hassle of moving across campuses
Questions to General Customers		
What are the necessary components of a classroom?	Chairs, writing surfaces, some sort of projector that is connected to a computer, whiteboards, easily accessible electrical outlets. Wi-Fi	10. The device includes media displays and seating/tabling options
		11. The device includes connectivity options such as internet access
What would you bring with you to an outdoors, educational experience?	Notebook and writing utensils, iPad, class materials, umbrella for shading or rain	12. The device allows users to set up their personal desk space like within a typical classroom setting
		13. The device provides shelter from the elements
Describe your ideal study or meeting space	In an area the size of a typical office space; a larger area that allows for personal space; a large table area to spread out	14. The device at normal capacity provides the ability to stretch out
What is your preferred shape for the educational experience?	U-shape, circling the speaker, modified U-shape, attendees in a circle with the speaker outside of it	15. The device's seating arrangement provides the participants the ability to view each other and requires the speaker to rotate to address them all
What does collaboration mean to you?	Cooperation of individuals that reach a common goal or mutual benefit	16. The device is structured to make it easy to interact with the other members

What tools do you find yourself using the most?	iPad, tablets, computers, smartboard, dry erase board	17. The device provides power for technological devices
		18. The device incorporates typical visual display options

The customer needs that were identified as the most important to the success of the project were 2, 5, and 10. These details define the mobility aspects, the customer's ability to utilize the device, and defining characteristics of the educational experience. As mentioned previously, the information within the table was gathered from interviews with the sponsor and with general customers. The members attempted to gain a broad perspective through interviewing a range of majors including communications, health sciences, engineering, and business. Questions aimed to provide an understanding of the current pros and cons associated with the current educational experience. Positives included the current display options within the classroom such as computer capabilities, whiteboards, and projectors. Negatives included classrooms that do not provide ample private space and the lack of interaction within the curriculum. The PUC aims to change the current dynamic y improving current issues and leaning on the current positives, with a focus on cooperation and critical thinking. The information gathered will be utilized throughout the design process, and further interviews may be conducted to ensure the project will be well received by the potential users.

1.3 Functional Decomposition

The objective of a function decomposition is to breakdown complex solutions into functional objectives like stages and steps in a process of forming a functional blueprint. For finding the project solution, creativity is a major factor so determining the necessary functions allows for determining more unique solutions. The information gathered from the customer needs interviews were utilized to determine the components of the functional decomposition. The functions were organized into hierarchical design and are shown below.

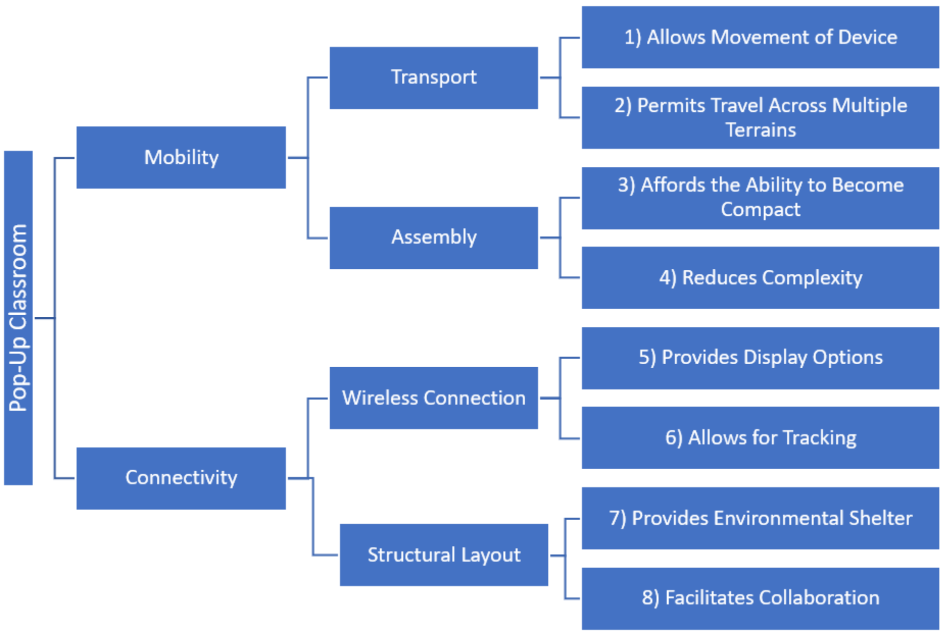

Figure 1 *Functional Decomposition Flow Chart*

The two systems that define the purpose of this device are mobility and connectivity. Mobility defines the nomadic aspects of the project as well as the associated moving parts. This includes transportation components and assembly aspects. Connectivity defines the experiences connected with promoting collaboration and providing typical components of the educational experience. Underneath this function there is wireless connection and structural layout. The following table provides insight to the connections across the main and sub-functions. Note that the rankings do not identify the most important functions but instead the functions that provide the highest possibility for innovation due to addressing a larger number of customer needs.

Table 2 *Cross Reference Table*

System				
Function	Related Customer Needs	Mobility	Connectivity	Ranking
1.	2, 4, 8	X		5
2.	4, 8	X	X	6
3.	9	X		7
4.	5, 9, 11, 16	X	X	2
5.	3, 10, 17, 18		X	2
6.	3	X	X	7
7.	4, 5, 13, 14		X	2
8.	1, 3, 5, 6, 10, 11, 15, 16		X	1
Ranking		2	1	

The table above shows the relationships amongst the different functions and how some overlap with both the connectivity and mobility systems. The connectivity system was shown to have more capabilities of innovative designs, particularly with function 8, facilitating collaboration. Each system works together to address the customer needs, with the components being used to address functions 2, 4, and 6 potentially addressing both mobility and connectivity aspects. Things to note during the design process would be finding a way to integrate the ability to be compact with the ability to facilitate collaboration, ensuring that the display devices do not get harmed while maneuvering different terrains, and that the environmental shelter and other appendages can be deployed easily.

1.4 Target Summary

The functional objectives determine the design target goals, which are established with metrics, so that the project progress is measured and tracked. The project's functionality revolves on how to influence a collaborative experience and mobility features. Functional decomposition and customer need we the basis to determine the project targets. The critical targets for the PUC are (1) user commodity, (2) a battery with an adequate capacity to power the device for 8 hours, (3) wireless connection and (4) a vehicle base that is sturdy enough to handle the load of the classroom, its users, and components. Refer to Table 1 in appendix C for the objectives discussed here.

Table 3 *Targets and Metrics*

Function	Target	Metric
1. Allows Movement of Device	There is a braking mechanism	Yes
	Wheels present and functioning	Yes
4. Reduces Complexity	Moveable components stay in place unless moved on command	Yes
	The design is intuitive	Yes, confirmed by a survey
6. Allows for Tracking	There is an admin portion to the online platform	Yes
8. Facilitates Collaboration	Provide enough room for 10-15 people to sit comfortably	The total seat widths exceed 25' (20" seat width x 15 people)
External to Defined Functions	Adequate battery life	> 5.1 kWh
	Device base can handle the weight of the components and passengers	Carries at least 500 lb.

As users utilize the PUC, they should be comfortable using it and its components. It is vital to include the essential components for learning and collaboration to ensure a functional classroom. There will be protection from the elements, internet connection, and media displays to assist with demonstration, learning, and user commodity. It is preferred that the PUC has modular capabilities. In other words, the components of the device should have multiple purposes to save space and optimize the use of device components. A compact, easy-to-use device will guarantee user comfort.

This technology-based device is intended for outside and mobile use; therefore, it will require power. The optimal way to provide power to this device is through batteries. E Source Companies estimated that classrooms average energy consumption of 2kWh for plug loads and 2.6kWh for lighting. The PUC depends heavily on technology use, so a full day use of it should consume the same amount of energy as the average classroom. Device set-up and tear-down should add an approximate 0.5kWh, so each 8hr session will consume 40.8kW. Batteries should satisfy the given energy demand. Once the electric hardware is chosen, more accurate and precise energy calculations will take place on Mathcad, then the results will be observed and analyzed with a simulation on MATLAB.

Connectivity is the main feature that will encourage collaboration among the PUC users. These should satisfy the most recent standards set by IEEE. These are the following: wave frequency of 2.4GHz and 5GHz, with maximum data rate of 10-12Gbps. These standard rates will increase network capacity by adding broadcast subchannels and allowing more simultaneous data streams. We expect that the PUC will be used by groups of two or more people, so it is relevant that the connectivity features allows for a fast and timely internet navigation.

The PUC's transportation depends on a suitable vehicle with adequate braking and suspension system. Moreover, the transportation vehicle should be capable of moving objects with the volume of a refrigerator. The focus point for the mobility feature are the following:

- Tire selection grade--either AA or A--to satisfy the different ranges of terrain traction.

- Breaking mechanism for parking and structural support.
- Vehicle suspension, which is determined by the spring stiffness and ductility so unwanted movements--such as vibrations and shifting--are prevented.

Tests for these aspects will be performed as we define their respective ideal values. Physical testing for tractions and braking will take place on various inclined surfaces to verify the calculated data. Once the suspension system is chosen, its information will be used in a simulation to provide a rough estimate of materials and ideal mechanical properties needed. Simulations concerning the vehicle performance and mobility will be handled on Adams View and MATLAB, while structural loading and FEA analysis will be calculated through Creo Parametric.

To summarize, connectivity and mobility aspects are fundamental for the PUC. More specifically, the design priority is its connectivity feature because it will provide the collaboration opportunities the PUC seeks to promote. On the other hand, the mobility feature is an aggregated functionality of the device. Targets and metrics for the specific components that enable the device's fundamental aspects will allow the engineers to keep tabs on the project as the design composition progresses.

1.5 Concept Generation

The point of the concept generation is to develop design ideas and concepts that will function as a solution to the problem at hand, no matter the feasibility. Various methods such as biomimicry and word association were used during group brainstorming sessions to achieve 100 concepts; which are available in the appendix. Ideas involving biomimicry tend to display that concept when discussing storage options, with collapsing and folding parts. Word association was used mainly with seating arrangements and displays devices, such as in concept 51, 52, and many other concepts; where media using images are circled or cornered in a way to influence collaboration.

Deciding the credibility of the ideas required assessing their physical legitimacy just as the potential issues that might be caused to the client. The rest of the ideas were then compared with the targets and metrics from Appendix C to check whether they were in accordance with the objectives of the venture. Through this correlation the group decided the ideas could be separated into specific functions. The ideas were sorted out by their usefulness and reason to make a morphological chart as appeared in the table below.

Table 4 *Morphological Chart*

Subproblem Solution Concepts			
Transportation Mode	Display Device Set-Up	Seating Arrangement	Storage Options
Towed by another vehicle	Using Holographic Displays	U-shape around the instructor	Collapsible parts for compact storage
Driven	TV monitors placed on the wall or walls	In a circle surrounding the instructor	Removable parts for disassembly and reassembly
Autonomous	Projectors used for displaying on surfaces	Audience style or V-shape out from instructor	Able to be parked in an average parking space or garage
Delivered to the location of choosing (PODS)	Smartboards	In rows in front of the instructor	Folds away

Utilizing the concepts determined through multiple brainstorming sessions and the morphological chart, we went on to compose complete concepts for the product. Fidelity for concepts was determined based on structural integrity, commitment to the functional requirements, assembly ability, and potential costs. After determining the fidelity of concepts, they were then split into medium and high-fidelity categories which are presented below.

1.5.1 Medium Fidelity Design

1.5.1.1 Design 1

Design 1 is made up of three major parts; the floor, projector stand, and 3D projector. This design's main concepts of focus were collaboration and compactness through modularity. The concept of influencing collaboration plays in hand with the floor functions, which is to come with retractable seats and can completely fold into a box casing that will hold the other parts during transport. To foster collaboration between everyone in attendance, a common point of focus for everyone will be the 3D projector attached to a support stand to elevate its position, which are primary components two and three. The 3D projection device will be a media display screen boxed in with reflective trapezoidal sides manipulating and splitting an image to produce a 3D projection. The greatest advantage of this idea is its ability to become compact; while media display device comes in second with the guided perception factor. By using this design solution, the speaker can lecture on concepts of multiple systems working in unison such as systems integration and the human body.

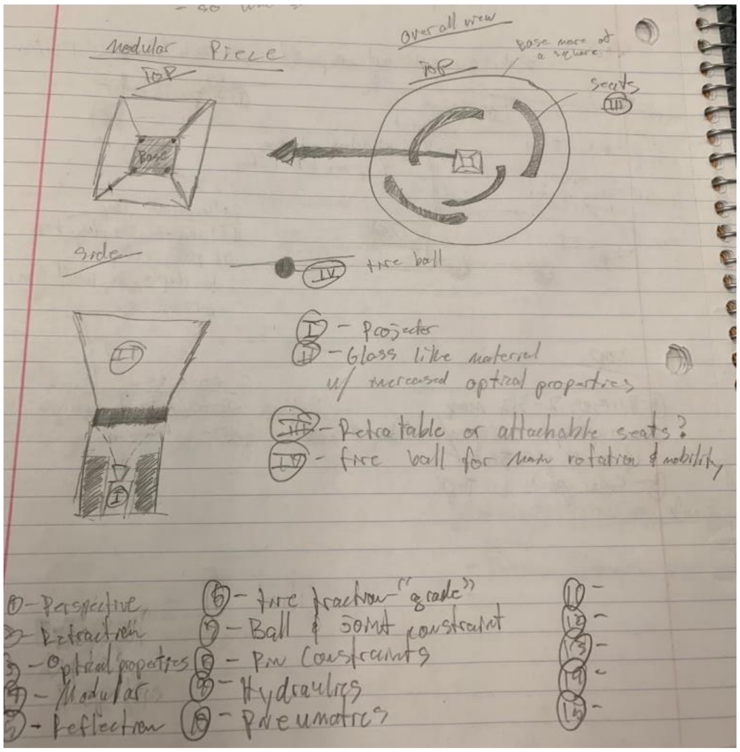

Figure 2 *Medium Fidelity Design 1*

This design concept has a weakness of not having developed 3D imaging technology. Due to the lack of available data and high cost estimates, this idea was ultimately determined to be unfeasible. Ideally it is preferred more than one media display for ease of viewing by larger audiences by providing options.

1.5.1.2 Design 2

Here in design II mobility and display devices are objective concepts engaged directly with this design. The PUC will be transported with a modified vehicle, where the surrounding body components of the vehicle also deploys and becomes the support structure while the media display deploys from the roof in a projector like fashion. For vehicle body components, transformation into structural support would be a mechanical process powered with electricity or pneumatic means.

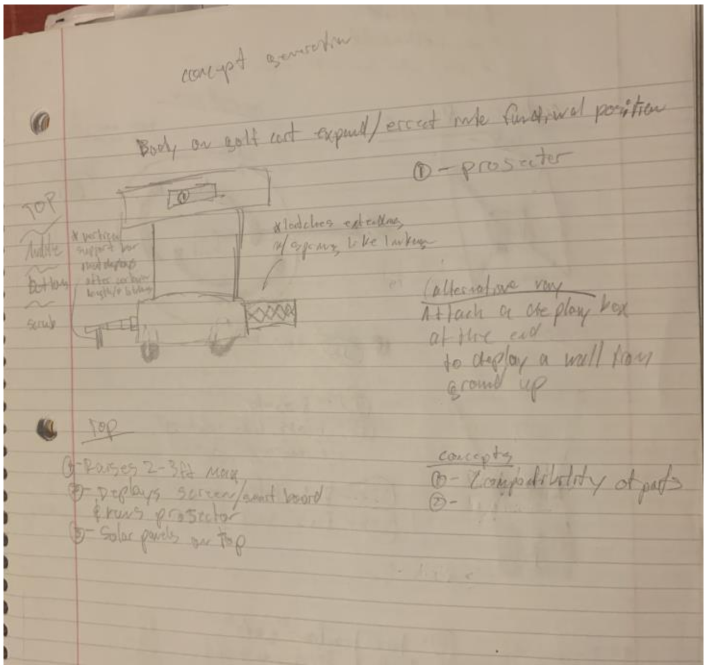

Figure 3 *Medium Fidelity Design 2*

This would have been a high-fidelity idea, but the initial idea was based off the LG foldable tv, but this technology is not available for commercial use yet; consequently, using multiple projectors for each side will take more resources which can be conserved through other design solutions. A weakness of this idea is its lack of focus on the collaboration aspect through the no seat specific or seating arrangement. To adhere to larger groups using the PUC, more material leading to higher power requirement will be needed, which will ultimately surpass ideal weight parameters.

1.5.1.3 Design 3

This design centers around a typical courtyard style table, while incorporating different teaching tools to ensure the methods of use are good. Projectors are located within the umbrella folds, stabilized by extra bars within the umbrella frame. This provides both display devices and protection from the elements. The projectors present onto the table and/or there are tablets within the table to show the presenter’s presentation. Chairs are rotatable to allow for the students to view the presentation specifically or to watch the professor, who can walk around the device on an elevated, grated platform that locks into an upper position during transportation. Not pictured is a handlebar that can be used to pull the device from place to place, which is located close to the wheels and has extending capabilities like a suitcase to allow for a comfortable towing height. The raised table in the center provides battery storage capabilities underneath the devices that require power, with wires being possibly fed through the umbrella pole to reach the projectors and lights (used for nighttime events).

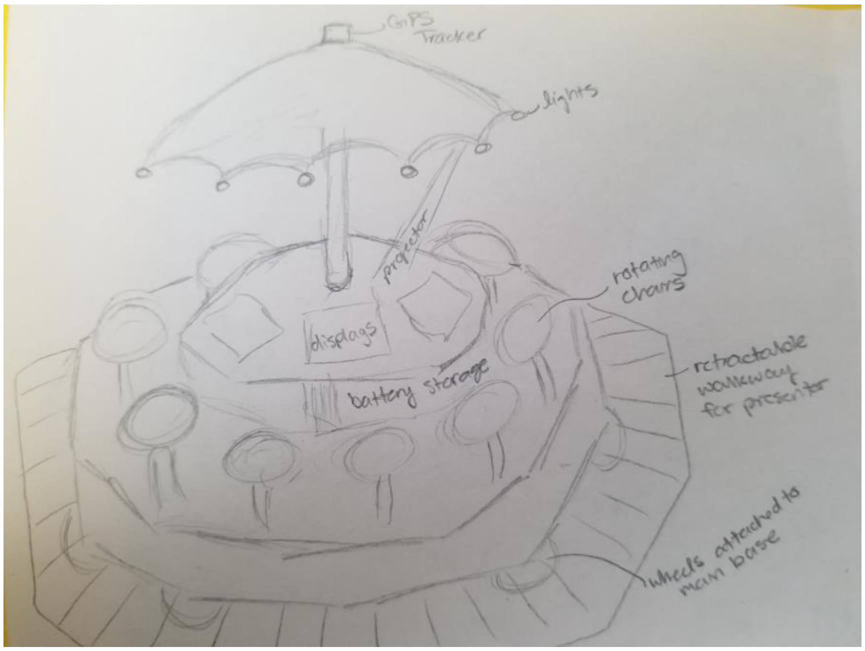

Figure 4 *Medium Fidelity Design 3*

Design 3 was determined to be of medium fidelity due to potential sizing issues and the amount of moving parts. The components provide an opportunity for compactness, but likely not within the metrics we had previously determined. The multiple moving parts bring up an issue with secureness and safety of the device, which would require multiple revolute joints and tightening mechanisms to ensure feasibility. Despite these downfalls and potential costs associated with multiple displays, it does provide a scene familiar to a lot of college students and a platform for a highly interactive learning environment.

1.5.1.4 Design 4

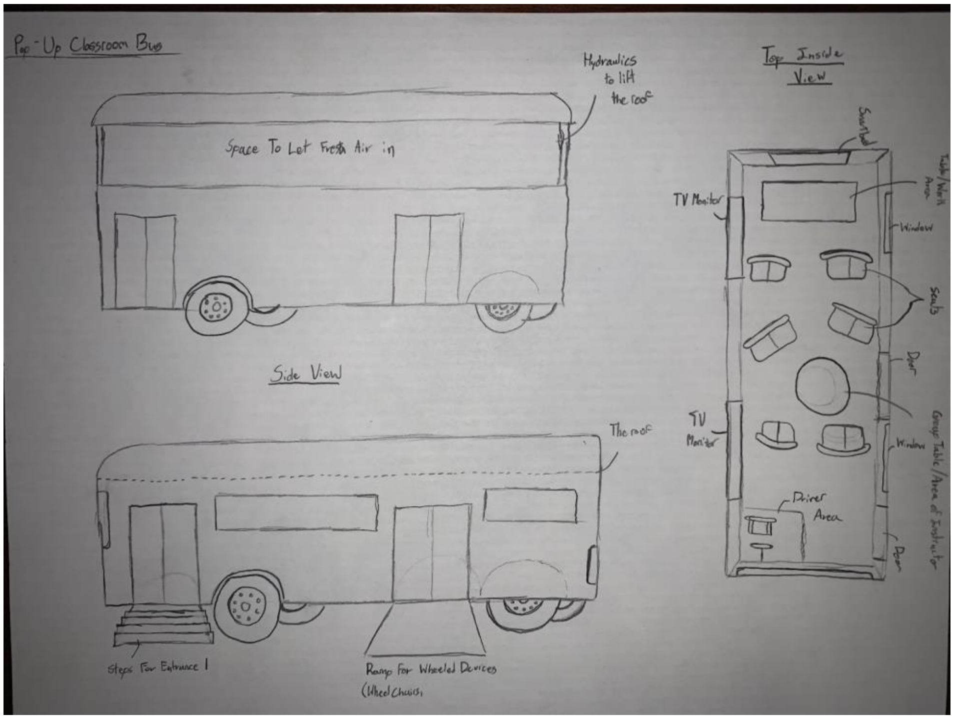

Figure 5 *Medium Fidelity Design 4*

Design 4 incorporates the use of a modified bus. The bus will have two entrances on the opposite side of the driver's seating position. One entrance will have steps closer to the front for quick access, the other entrance will have a ramp that will allow for wheeled device access like wheelchairs and scooters. The windows would be able to open to let in fresh air. The roof would be raised using hydraulics to create a more open learning environment. Inside, the arrangement will be that of a classroom that promotes interactivity and creativity. There is enough seating for at least 10 individuals and would have all the electric and media needs. The seating would be around the speaker or a central circular desk. There would be a smart board on the rear wall and a workspace as well. TV monitors would be on the opposite wall of the doors.

1.5.1.5 Design 5

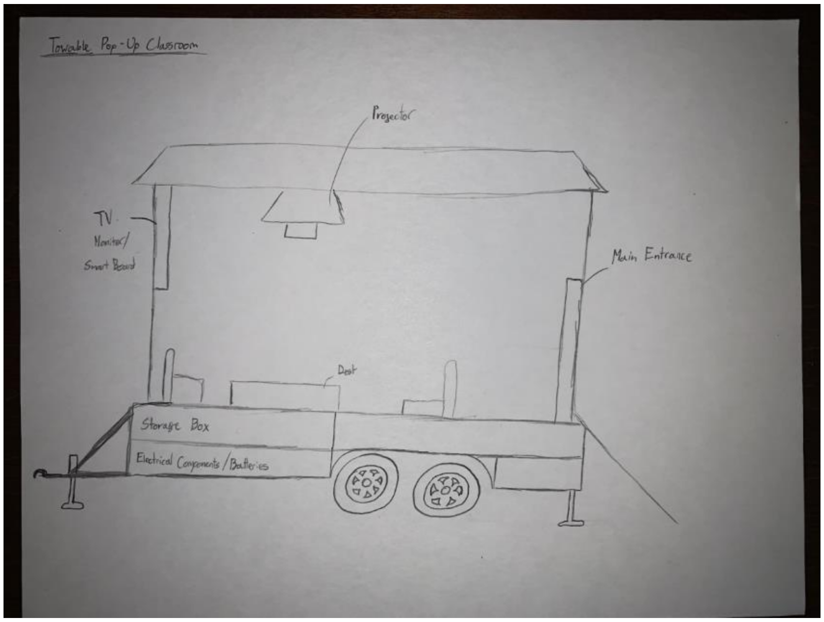

Figure 6 *Medium Fidelity Design 5*

Design 5 focuses on the Pup-Up classroom being towed by a standard pick-up truck. The classroom would be built on top of a trailer deck with all the storage for classroom items in storage boxes underneath. Below the storage boxes are the batteries and electrical components to supply power to all the devices within the classroom. This design is more open to the environment and lightweight. The class seating would be in a circle around the speaker or main point of interest. On one wall there will be an area for a smartboard, a TV monitor or dry erase board.

1.5.2 High Fidelity Design

1.5.2.1 Design 1

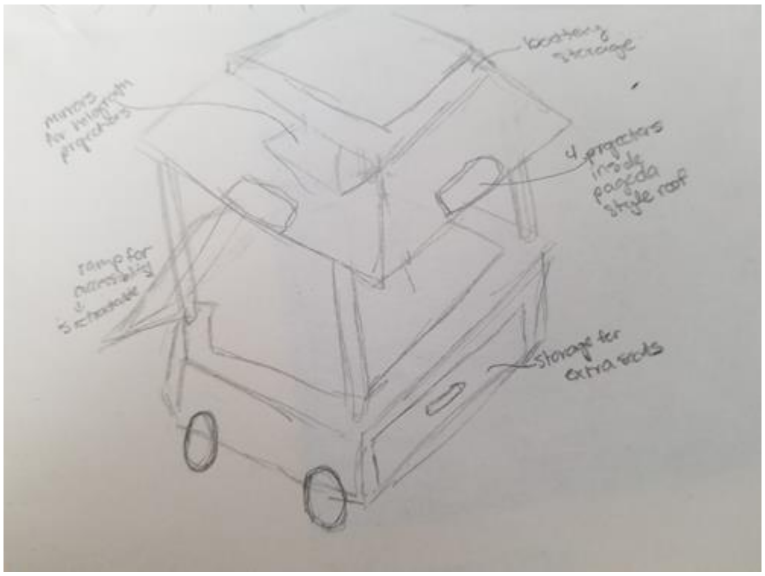

Figure 7 *High Fidelity Design 1*

This design is a cart with a roof to protect from rain and block some sunlight. It includes some storage compartments for the seats, a ramp to allow wheelchair access, a battery storage compartment overhead to power all the electronics, and projectors pointing towards all four directions.

1.5.2.2 Design 2

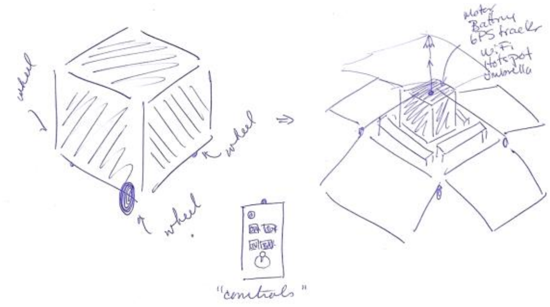

Figure 8 *High Fidelity Design 2*

Design 2 is based on the blooming process of lotus flowers and was developed with the bubble brainstorming tool in which relations between individual concepts are shown. The latter focuses on the inner connections and features the PUC will have. This includes (a) the mechanical aspect and (b) the electrical part. For (a), it's a vehicle that can easily move through terrain on three wheels and drives itself with a remote control (like a toy car). The remote driver allows for the absence of a "driver's seat", therefore more space for the classroom and its users. The remote control then is the user-device that will instruct the classroom to transform as needed/requested by the users. The PUC is condensed into a cube that opens like a lotus flower when it blooms with the touch of a button. Inside there are benches, a table and rolling displays. The battery, GPS tracker, Wi-Fi, electrical wiring, and motor are inside the table at the center of the cube.

1.5.2.3 Design 3

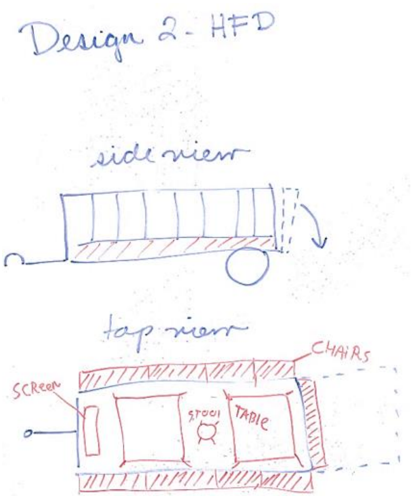

Figure 9 *High Fidelity Design 3*

This design is in the style of a typical trailer towed from a pick-up truck or equivalent. It will have two wheels on a single axle, with off-road tires. It will have chairs placed around the perimeter of the trailer. The center of the trailer will feature tables for students/participants to have something to write on or place their computer. There will be a comfortable, but unrestrictive stool for the instructor in the middle of the trailer. The front of the trailer will have a screen that the instructor/lead can display something from their connected device. The trailer will provide WIFI to enable connectivity.

1.6 Concept Selection

Ideas produced from the concept generation are ranked and the most ideal choice among the concepts generated will be selected. Concept selection tools such as binary comparisons of engineering characteristics, House of Quality charts, and Pugh charts will be used to determine which idea is the best solution to proceed with for product development. Engineering and customer parameters were first prioritized and ranked. This binary chart helped streamline past minor steps in the concept selection process for smoother transition between steps so the group could determine the best solution based on priority of functional objectives. As displayed below the ranking of product characteristics started off with power consumption and mobility being in a tie for first; followed by another tie between weight and user interface for third, making these the top four engineering characteristics. Weather resistance, area, and aesthetics occupy the latter ranking of spots fifth through seventh.

Table 5 *Binary Selection Table*

Engineering Characteristics	Weight	Mobility	Power Consumption	Area	Aesthetics	Weather Resistance	User Interface	Totals For Checking Purposes
Weight	1	1	1	0	0	0	0	3
Mobility	0	1	0	0	0	0	1	2
Power Consumption	0	1	1	0	0	0	0	2
Area	1	1	1	1	0	1	1	6
Aesthetics	1	1	1	1	1	1	1	7
Weather Resistance	1	1	1	0	0	1	1	5
User Interface	1	0	1	0	0	0	1	3
Totals	5	6	6	2	1	3	5	
Rank	3	1	1	6	7	5	3	

The House of Quality chart was used to factor in the customer needs into the concept selection process. In the House of Quality chart customer needs are weighted and integrated with the engineering characteristics. By using the target and metrics determined earlier the engineering characteristics and customers' needs can be directly correlate to each other. Importance weight factor correlates to the rankings assigned from the binary comparison chart. Customer requirements were ranked as 1-6, with 1 being the most important; while the relationship matrix formed by comparing engineering characteristics to customer requirements, with contribution to fulfilling the customer requirements based on significantly (9), moderately (3), slightly (1), or left blank if no impact. Based off the chart below moveable components, intuitive design, and comfortably seating 10-15 people were decided to be the top three objectives; while battery performance, weight tolerance, wheels and brakes, and administration control were lower ranked targets. Engineering characteristics without metrics attached to them can be treated like a checklist item when completed, but for the sake of bureaucracy of this project they will yield the simple result of yes or no.

Table 6 *House of Quality Chart*

		Engineering Characteristics						
Improvement Direction			↑	↑			↑	↑
Units			lbs.	#			m^3	kwH
Customer Requirements	**Relevance Weight Factor**	**Wheels and brakes are present**	**Device weight tolerance**	**Movable parts stay in place**	**The design is intuitive**	**There is an admin portion to online platform**	**Provide enough room for 10-15 people**	**Adequate battery performance**
Weight	**5**	1	3	3			3	3
Mobility	**7**	9	9	9	3	1	1	
Power Consumption	**7**				9	1	3	9
Area	**2**	3	3	9			9	3
Aesthetics	**1**	3	1	9	9	1	3	1
Weather Resistance	**3**		1	1	1			3
User Interface	**5**			9	9	9	1	
Raw Score (155)		16	17	40	31	12	20	19
Relative Weight %		10.3	11.0	25.8	20.0	7.70	12.9	12.3
Rank Order		6	5	1	2	7	3	4

After the House of Quality prioritized the functional objectives from the customer needs, it was time to start narrowing down ideas and concepts through multiple iterations of the Pugh chart. A plus (+) was awarded to concepts which were considered better than the datum while a minus (−) was awarded to concepts which were considered less than the datum. Concepts considered to be about the same as the datum were awarded an S.

Table 7 *Initial PUGH Selection Chart*

		Concepts							
Selection Criteria	**Work on Wheels**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Movable components stay in place	DATUM	S	S	-	+	S	S	+	S
Design is intuitive		+	S	-	+	S	S	s	+
Enough space for 10-15 people		-	S	+	+	S	+	s	+
Adequate battery performance		+	+	+	-	+	+	+	+
Device Weight Tolerance		+	+	-	-	+	+	+	+
Wheels and brakes are present		S	S	S	S	S	S	S	-
Admin portion is available on online platform		+	+	+	+	+	+	+	+
# of pluses		**4**	**3**	**3**	**4**	**3**	**4**	**4**	**5**
# of minuses		**1**	**0**	**3**	**2**	**0**	**0**	**0**	**1**

In the first iteration of the Pugh chart shown above, design concepts discussed earlier were placed and scored relative to the datum concept of mobility. Comparing concepts in terms of mobility was a vital first step in the filtration process, because one of the primary objectives was for the device to be mobile and if the concept is having a hard time being mobile in thought then it does not even need to be considered until this issue is resolved. With that being said, 4 was the first to be eliminated in the pursuit of best concept generated and concept 3 (see Fig. 4 above) became the datum concept.

For the second iteration of the Pugh chart, concept 3 was chosen to be the control concept to be compared among the other generated concepts. Concept 3 weaknesses relative to the other concepts are inferior on the premises of mobility, intuitiveness, and weight tolerancing. Concept 3 is just a mobile computer lab, which is not what the customer asked for. Excluding concept 1, concept 2 had the lowest pluses to minus ratio leading to elimination of this idea based off relative inferiority.

Table 8 *Secondary PUGH Selection Chart*

		Concepts					
Selection Criteria	**3**	**1**	**2**	**5**	**6**	**7**	**8**
Movable components stay in place	DATUM	S	+	+	S	S	+
Design is intuitive		+	S	+	+	+	+
Enough space for 10-15 people		-	S	+	S	+	+
Adequate battery performance		-	-	S	S	-	-
Device Weight Tolerance		+	+	-	+	+	+
Wheels and brakes are present		S	S	S	S	S	S
Admin portion is available on online platform		S	S	S	S	S	S
# of pluses		**2**	**2**	**3**	**2**	**3**	**4**
# of minuses		**2**	**1**	**1**	**0**	**1**	**1**

Even though concept 1 (see Fig. 2 above) had the most number of minuses, it was first proposed by our advisor which added a slight bias to the Pugh chart so we made it our datum point concept for the final Pugh chart iteration. Since concepts 2 & 3 were eliminated due to weight tolerance issues, and budgeting limits, then it was time to move onto the next Pugh chart.

In the final iteration of the Pugh chart, concept 1 was used for the datum concept to be compared to concepts 5,6,7, and 8. In the chart below it became prevalent that our bias in concept 1 was in error. Looking at the chart results, concept 5,6, and 7 were all better choices relative to concept 1 because only one concept had a minus after comparison.

Table 9 *Third Pugh Selection Chart*

		Concepts			
Selection Criteria	**Concept 1**	**5**	**6**	**7**	**8**
Movable components stay in place	DATUM	+	S	+	S
Design is intuitive		+	+	+	-
Enough space for 10-15 people		S	+	S	S
Adequate battery performance		S	S	+	+
Device Weight Tolerance		+	S	+	+
Wheels and brakes are present		S	S	S	S
Admin portion is available on online platform		S	S	S	S
# of pluses		**3**	**2**	**4**	**2**
# of minuses		**0**	**0**	**0**	**1**

After comparisons were made in respect to the decided judgment parameters and other concepts; concepts 1 and 8 were removed. Progressing the selection process to the final step, analytical hierarchy process chart, to decide which concept- 5, 6, or 7; will be developed.

Table 10 *Criteria Comparison Matrix*

	Movable Components Stay in Place	Design is Intuitive	Enough Space for 10-15 People	Adequate Battery Performance	Device Weight Tolerance
Movable Components Stay in Place	1.000	0.333	3.000	0.333	3.000
Design is Intuitive	3.000	1.000	3.000	0.333	3.000
Enough Space for 10-15 People	0.333	0.333	1.000	0.333	1.000
Adequate Battery Performance	3.000	3.000	3.000	1.000	5.000
Device Weight Tolerance	0.333	0.333	1.000	0.200	1.000
Sum	7.667	5.000	11.000	2.200	13.000

From the table above, it can be shown that the criteria with the most importance is enough space for 10-15 people. Also, it is important to note that the criteria weights passed the consistency check, which shows that even with our biases, the concept selection tools used reduced our bias enough to not be able to affect the results. Using this information, separate AHPs for each criterion relating the concepts were created. After additional calculations, we were able to determine the optimal concept in the table below, which was concept 6.

Table 11 *Consistency Check*

	Weighted Sum Vector	Criteria Weight	Consistency
Concept 5	0.320	0.106	3.011
Concept 6	1.946	0.633	3.072
Concept 7	0.790	0.260	3.033

1.7 Spring Project Plan

The tasks that need to be completed and their tentative due dates for the Spring 2020 semester are listed below. These tasks were made during the Fall 2019 semester and are subject to change.

1. Conclude Parts Selection — Due Date: 01/15
2. Order Components — Due Date: 02/05
3. Assembly — Due Date: 03/01-03/31

4. Testing Due Date: 04/01-04/15
5. Finalize Project Due Date: 04/17
6. Final VDR Due Date: TBD
7. Engineering Design Day Due Date: 04/21
8. Finals Due Date: 04/27-05/02

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1.8 Restated Project Definition and Scope

After careful consideration and design reviews with the project's advisors and sponsor, the design was modified. It was determined that the chosen design was not the most feasible, that it would lack mobility, that it wouldn't have the "motion-by-control" feature and it would not be compact. Therefore, the Electrical Engineering department at FAMU-FSU College of Engineering offered a former Senior Design Project from which the PUC can be built from. The former project is called "The Robotic Trash Can" (see Figure *10*). Its frame, wheels, and electric components are to be left intact; but its software and circuit components must be updated. The new design modifications include accessibility for the user, device motion controlled by remote, and a compact aesthetic.

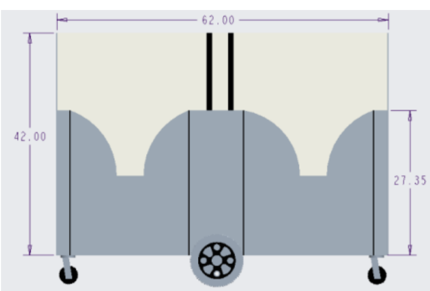


Figure 10 *Robotic Trash Can Frontal View*

The new design (see Figure *11*) includes many of the initial features that the sponsor asked for. First, the design includes a controller to move the device remotely. Meaning that, in a future iteration of the project, it can be fully automated and self-driven. Second, the device includes many of the classroom teaching tools. The top three most important are a TV display for casting capabilities, whiteboards, and wireless connectivity for personal devices. Third, the PUC has a roofing component that provides weatherproof capability to the device and its components. Finally, the design offers more accessibility to users, as it works as the center of the meeting and people can gather around it.

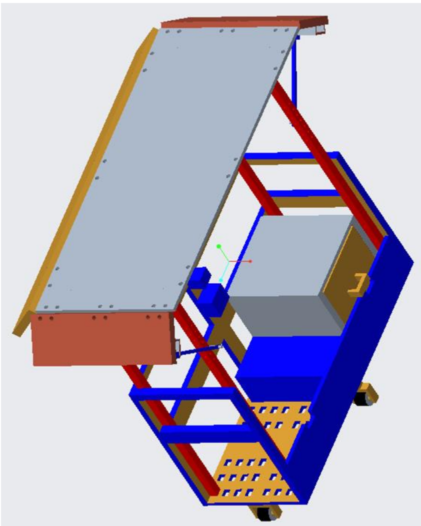
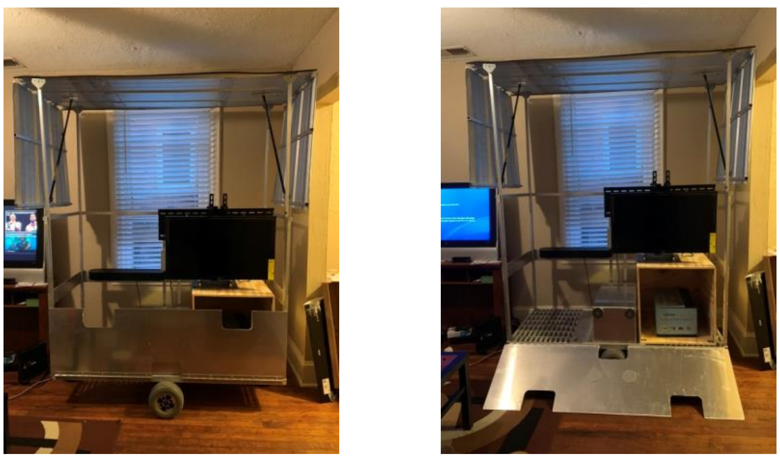


Figure 11 *CAD Render for updated design*

1.9 Results and Discussion

The resulting PUC is very close to the design (see Figure *12*). The roof displayed an accumulative 6% strain from the static loading testing conducted. The roof had a total mechanical deformation of about 5 inches from beginning to end of testing, averaging a rate of deformation of 1 inch per 20 lbs. After conducting stress calculations, it was determined that it would fall short of the 300lbs failure load, therefore agreeing with the data obtained from simulations.

Maneuverability is a major aspect for the PUC as it must traverse through college campuses. It would need to be able to travel up hills, around corners, on different terrains, and be compact enough for easy storage and not be in other's way. The highest inclined that the device would take was designed to be between 5 and 8 degrees due to weight distribution, design of the cart and friction of tires. The cart has a zero-turn design so it will theoretically have a zero-turn radius. This is accomplished by having the device is driven by two motorized wheels in the middle of the frame with two caster wheels for additional support.



(a) (b)

Figure 12 *Completed PUC: (a) gate is closed, (b) gate is open.*

Results from the static roof loading test displayed a strain of deformation below 10%. A reasonable correlation to the total bending of 5 inches in the roof, a result from complete loading. Measurements were from the base of the cart to the bottom of the roof, measuring a total 78 inches before loading. For the dynamic loading of the cart's roof using the tractor, it was observed that vibrations travel in the same direction of initial motion and showed fundamental wave behavior when an opposite wave or a damper was involved.

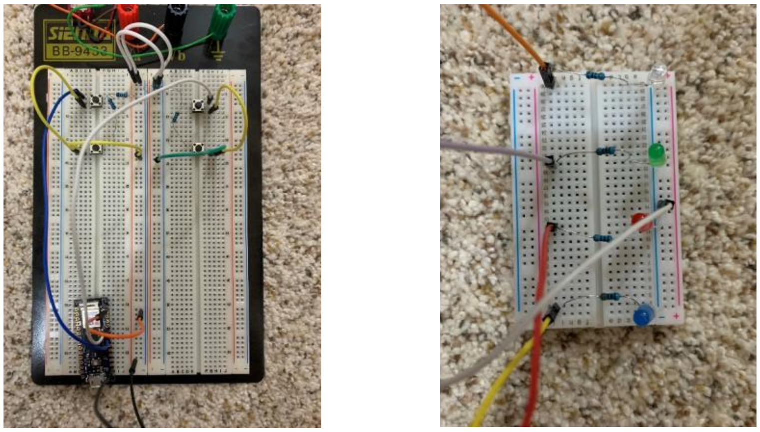
For the battery testing, the cart was able to maintain a 25.6 V voltage but the current varied and decreased with time of use. The first test for the cart was a direct load analysis with four ppl each weighing at least 130 lbs and seeing if it could still move. For the testing of the cart while on different terrain; the cart did not have a problem starting or stopping when on dry land but there was a delay to gain traction. Problems with traction were also visualized when trying to move up an inclined sidewalk and the cart experienced slipping earlier than the dry run on the same sidewalk.

The ordering website's final design matches the PUC's design goals and its information is expected to positively impact the user's decision to book the PUC. The website includes four main sections for the user to interact with. First, the booking section (see includes a form for the user and contact information for further assistance. Second, the about section details who is CRI and it includes a FAQ portion in which the user can know more about the PUC. Third, the services section illustrates the ways that the PUC can be used, demonstrating the device's versatility. Finally, the testimonials section is available for future product reviews that upcoming customers can refer to. It is considered that each of these sections will positively impact the user's decision to book a PUC.

The website's design goals match those selected for the PUC device: intuitive, minimalist, appealing, and interactive. Refer to the Appendix F: Website for website snapcshots. The booking process depends on the collaboration between the .html and the .php files. These hold the information that the user interacts with at the website and the steps to process the input information, respectively. It is of utmost importance that these files work correctly, as they will allow the user to input their information to the booking form and CR can access that information in an effective manner. The website files will be given to the sponsor along with the PUC device when the project wraps up. Intentionally, the design goals chosen for the website and the PUC are the same because the different product components work as a whole.

Regarding the coding reactions and responsiveness, the following was found since the coding implemented in the Arduino Nano is not so complicated as to process several different things, the Arduino Nano takes user input and interprets it almost immediately. With a good connection, commands from the Arduino Nano to the Raspberry Pi will transfer almost instantly. The Raspberry Pi's code also processes commands almost immediately. The Raspberry Pi is connected directly to the cart itself. This ensures that any commands the Raspberry Pi receives, via Bluetooth or backup keyboard input, will yield immediate output, and an immediate movement of the cart, assuming the cart is powered properly. This was not able to be physically tested due to environmental circumstances. The backup keyboard option for user input will have an even faster response time, but this is at the cost of carrying around a wired computer keyboard to operate a nomadic device, making the operation less comfortable than using a wireless controller. The time that the wired keyboard saves compared to the Arduino Nano is also negligible in almost all intended applications.

In terms of verifying the coding aspects, the team was unable to do so in a way that would yield accurate results due to the cancellation of various parts. Instead, the team implemented code testing using the hardware and software aspects that are included in both the Arduino component and the Raspberry Pi component. Testing the code on the Arduino itself is easily done by using a simple LED that is built into the board. By having the code blink the LED in a certain fashion based on user input, we used that to verify the success of the code on the Arduino level. Then, we had to connect the Arduino and Raspberry Pi via Bluetooth. In this way, we can relay the Arduino's commands to get the Raspberry Pi to move the motors in a way that results in movement of the cart. Again, without critical components we needed to implement another method of testing. This is done by using the Raspberry Pi's console output. By using the console output, we could verify that the Raspberry Pi and the Arduino are both communicating and behaving appropriately as to carry out commands to move a cart, should the cart itself be working.



(a) (b)

Figure 13 *Arduino and Raspberry Pi Testing Circuit*

1.10 Conclusions

The device achieved its original goals, and through testing the team determined methods to improve the overall design. Testing techniques were defined for later verification of various components affected by the inability to get a new battery. We have laid the groundwork for future iterations to incorporate an autonomous component to the device once these initial tests are completed.

1.11 Future Work

The basic frame of the cart is completed but converting it into the PUC is not completed. The batteries need to be replaced, since the current batteries do not have enough power due to extended time of disuse. The code is complete besides the aspects regarding connecting the hardware. Once hardware connection is completed, the code should be troubleshooted and fully implemented into the system. Due to the current situation, some of the components needed had their orders canceled (such as AV Cabinet, new batteries, white boards, mic), with a full list being defined within the BOM. Some of these components can still be purchased through personal funds and the BOM will be updated accordingly. The basic structure of the device is complete, though, the media devices just currently do not have a power supply nor are they attached to the PUC.

The product's user experience needs to be reviewed, evaluated, and updated accordingly. Due to the current social restrictions because of COVID-19 the PUC is missing feedback from users. When the situation allows, test groups should try out the PUC device and give feedback to CRI about their experience for product improvement. Moreover, the product website requires a review and troubleshoot for the booking form process. The files involved are the .html and the .php files. The website may require occasional maintenance and coding review if CRI wants to remove/add information.

1.12 References

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Appendices

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Appendix A: Code of Conduct

Mission Statement

The team seeks to push the boundaries of the current educational environment by creating a device that provides for simultaneous collaboration and instruction outside of the typical classroom setting.

Team Roles & Description

This section defines the member roles and descriptions, with the organization consisting of the member's major, career aspirations, and roles within the team.

Daziyah Sullivan

A senior mechanical engineering major from Jacksonville, FL. Her dream job is to be a design engineer, with a love for the engineering design process. She is also interested in adjacent jobs such as product development and research and development engineering. Her primary role within the group will be serving as the Project Manager. This involves keeping track of the progress of the project by tracking activities against dates, determining timelines and assigning roles for specific tasks, and ensuring the project charter guidelines are being followed.

Jean P Roquebert

A senior computer engineering major from Panama City, Panama. His dream job is to work as a Programmer / Software Engineer. His primary role within the group will be serving as the Software Engineer. This involves determining applicability of software to the project, designing and implementing code to carry out specific tasks, and debug codes when applicable.

Kyle Jackey

A senior computer engineering major from Panama City, FL. His dream job is to be a drone pilot in the Air Force. His primary role within the group will be serving as the User Experience Engineer. This involves creating and maintaining customer surveys, maintaining the customer mindset throughout the design process, and providing possible adjustments to accommodate different customer sectors.

Michael Johnson

A senior mechanical engineering major from Pensacola, FL. His dream job is to be a senior engineer and board member for research and development within a company, supervising and facilitating ideas for concept development. His primary role within the group will be serving as the Prototype Developer. This involves tracking ideas of members during brainstorming sessions, furthering development of applicable ideas and determining their feasibility, and finding/utilizing prototyping resources from the universities.

Valeria Bernal

A senior electrical engineering major from Panama City, Panama. Her dream job is to assist in ethical engineering practices to assist communities that have been affected by political and economic disruptions. Her primary role within the group will be serving as the Communications Specialist. This involves keeping the team members and stakeholders informed, sending email communications, and ensuring that information presented or submitted is acceptable.

Yahdid James

A senior mechanical engineering major from Jacksonville, FL. His dream job is to be in the automotive industry, with specific goals being to work with Ford Motor

Company to gain industry experience then starting an independent automotive company. His primary role within the group will be serving as the Vehicle Engineer. This involves determining methods for incorporating motion into the product, accounting for the possible terrains, and finding techniques that could be utilized in later iterations for autonomous capabilities.

It is important to note that the primary roles mentioned within each member description is not indicative of their full roles. Each member is expected to contribute in every capacity that they are willing and able to. As the timeline progresses, primary roles are subject to change to ensure that members are contributing to tasks that are in line with their strengths. Tasks not covered within the role descriptions will be delegated by the Project Manager to team members that are able to complete them.

Attendance & Communication

Article I: Attendance

The project work schedule is divided into two periods:

1. September to December (Fall)
2. January to May (Spring)

During each period, each team member is allowed four (4) excused absences and two (2) unexcused absences. An excused absence is an absence from a team, advisor, or sponsor meeting, for which fellow members were notified of at least twenty-four hours in advance. Excused absences may include, but are not limited to illness, traveling, and/or studying reasons. After four (4) excused absences, all other absences are unexcused. Failure to notify the team of an absence twenty-four hours ahead of time will result in an unexcused absence.

The possible types of meetings are:

- Whole Team Meeting (WTM): all six members must attend the team, advisor, or sponsor meeting.
- Partial Team Meeting (PTM): assigned members must attend the team, advisor, or sponsor meeting. Examples include, but are not limited to: ECE department meeting, ME department meeting, design meeting, programming meeting, etc.

The team meeting type will be determined when planning the meeting.

Article II: Meeting Requirements

Meetings are due to be scheduled at least twenty-four (24) hours in advance. They will occur with the following frequency:

- WTMs will occur at least once a month.
- PTMs will occur as frequently as needed.

Advisor meetings will occur on a monthly basis and sponsor meetings will occur biweekly.

Article III: Communication Channels and Contact Person

The primary communication channels for the team and their intended purpose are as follows, with appropriate response delays noted in parentheses:

- Basecamp (24 hours): notify absences, schedule meetings, ask project-related questions.
- GroupMe (48 hours): notify absences, discuss trivial matters.
- Google Calendar (24 hours): schedule meetings.
- Google Drive (2 business days): meeting minutes, project documents.

Project updates will be communicated to the team through meeting minutes (MMs). These will be shared on Google Drive, so that team members can access the information remotely. MMs are expected to be complete, insightful, and informative. Meeting minutes will be primary source for attendance tracking, with a separate living document being maintained to document absence categorization.

The team's contact person is Valeria Bernal. She will communicate with outside resources--such as our advisor, sponsor, or counsel--regarding budget, inquiries, and/or clarifications concerning the senior design project. Emails with outside resources will be responded to within 2 business days.

Ethics

This project is a redesign of the current classroom and therefore will lean on previous research and concepts throughout the design process. Each source of ideas and inputs will be given proper credit within reports and presentations. Creativity will be promoted through the acknowledgement of specific team member inputs. There will be no copyright infringement, plagiarism or stealing of ideas in any fashion. This project will be conducted with honesty and with high integrity. The device intentions are for educational and collaborative purposes, and members are expected to keep this in mind throughout the design process. We are not building a weapon.

Dress Code

The following information outlines the expected apparel for team members in different settings.

- ***Presentations***: Business Professional, note that similar colors should be worn during presentations to promote the appearance of cohesiveness
- ***Advisor meetings***: Casual
- ***Team meetings***: Casual
- ***Customers***: Business casual
- ***Sponsor meetings***: Business casual

These dress code terms follow typical conventions associated with the phrases.

Conflict Resolution

There are multiple issues that may arise throughout the course of the project, the following information provides steps for conflict resolution in a few of the potential issues.

- Design Direction Conflicts
  - Should conflicting views of design direction arise, a meeting between the two conflicting parties will meet to solve the issue. If an agreement cannot be reached between the two conflicting parties after three days, the issue will be discussed among the entire group. If the group cannot reach a compromise after five days of the initial disagreement, the Project Manager will decide or ask for support from the Faculty Advisor.
- Attendance Conflicts
  - Absences will be recorded within a living document on the Google Drive. When nearing the number of accepted absences, the member will be notified that their contributions will be monitored closely. Once the member has reached the absence limit, the team will evaluate their contribution and decide on whether to escalate the issue.
- Vacation Day Use
  - The team reserves the right to deny a request for the use of a vacation day for a team assignment. If someone requires an extension, the team will work to distribute their tasks for that assignment amongst the remaining members. That member will then be expected to carry more tasks in the next assignment. If the member does not give advance notice of their inability to complete their tasks so

that the rest of the team may accommodate, the team may vote on whether to inform the senior design instructor with three members voting yes warranting this response.

Statement of Understanding

By signing this document, I acknowledge that the contents within will govern the actions of the group and agree with all terms set forth.

Daziyah Sullivan	4/21/2020 Date
Jean P Roquebert	4/21/2020 Date
Kyle Jackey	4/21/2020 Date
Michael Johnson	4/21/2020 Date
Valeria Bernal	4/21/2020 Date
Yahdid James	4/21/2020 Date

Appendix B: Functional Decomposition Chart

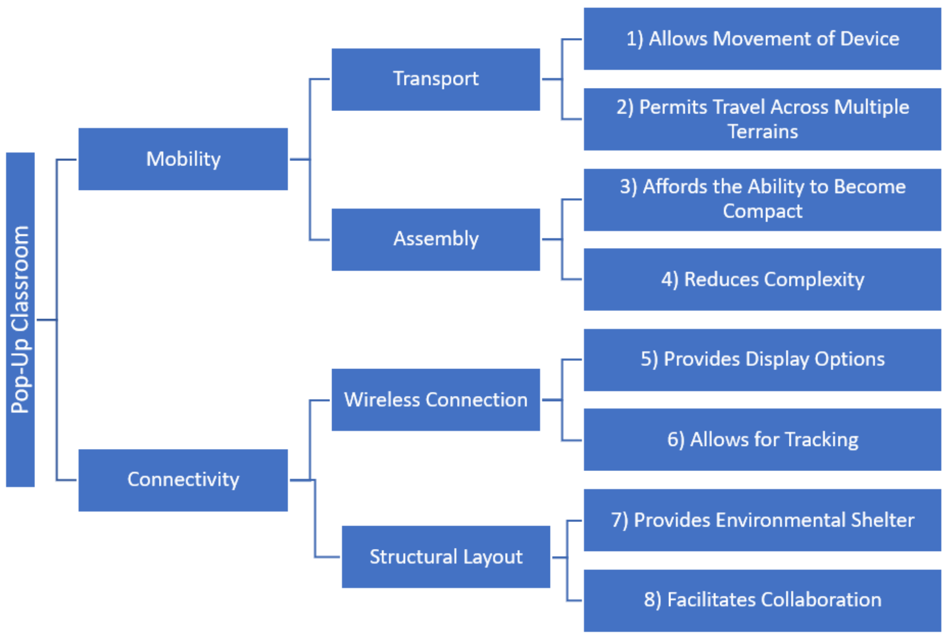


Figure *1* Functional Decomposition Flow Chart

Appendix C: Target catalog

Function	Target	Metric
1. Allows Movement of Device	*Wheels are present and functioning	Yes
	*There is a braking mechanism	Yes
	Device is in an allowable weight range for transportation	Weight < 500lbs
2. Permits Travel Across Multiple Terrains	Device can travel across pavement and golf course grass, and can travel uphill at 15°	Traction coefficient > 0.9
3. Affords the Ability to Become Compact	The device can be stored	Stored volume < 32 cubic feet
	Components have multiple uses	25% of components have two or more uses
4. Reduces Complexity	There is a manual for operation questions	Yes
	*Moveable components stay in place unless moved on command	Yes
	*The design is intuitive	Yes, confirmed by a survey
5. Provides Display Options	Device is equipped with display options	Yes
		Yes

	Provides power for the display options on the device	The battery for the device can store power for 8 hours of operation
	The presence of wireless connectivity through Wi-Fi or through Bluetooth	The range of the connection = the boundaries of the device + 6 feet
6. Allows for Tracking	There is an online platform associated with the device	Yes
	Vehicle is equipped with GPS	Yes
	*There is an admin portion to the online platform	Yes
	Order history is stored within the online platform	Yes
7. Provides Environmental Shelter	Roof is opaque for shading purposes	Yes
	The seats are elevated above the ground - seat height > 25’’	Seat height relative to ground > 25”
	Roof component partially blocks the rain	The roof extends 12”, angled perpendicular to the incoming rain
8. Facilitates Collaboration	Seating dimensions are within typical guidelines, with higher than average width	15 < Depth < 18 in 20 < Width < 25 in 16 < Knee Height < 18 in 12 < Bench Back Height < 16 in (if applicable)

	* Provide enough room for 10-15 people to sit comfortably	The total seat widths exceed 25' (20" seat width x 15 people)
	The seating arrangement is organized for there to be participant interaction	>50% of seating is facing other seating
External to Defined Functions	*Adequate battery performance	> 5.1 kWh
	Wireless performance	Meets IEEE standard 802.11ax
	Complies with ADA standards	Yes
	Device base can handle the weight of the components and passengers	Carries at least 500 lbs.
	Set up and take down quickly and efficiently	Set up and breakdown time < 4 min

List of Concepts

1. Smart car that transforms into the classroom
2. Expandable, automatic cube
3. Attached to a vehicle (like a trailer)
4. Lotus flower opening
5. Display screens can roll, touch screen, and visible for every angle
6. Pearson PUC introducing digits: open one which can open another, 3D, consecutive reactive "miscarry" of components
7. Acoustics: speakers around the umbrella

8. Light if meeting at night under the umbrella
9. Picnic table layout (round)
10. Tent-inclined design
11. Spider-like mobility, with legs supporting the bubble-classroom and it can open its shell
12. Built-in tablets for screen mirroring to that of the professor
13. Cloud-based teaching
14. Transformers: vehicle to classroom
15. Utilize dressers to store extra chairs
16. Use a pagoda-style roof to allow for media display device storage
17. Use multiple projectors for display so that the images can be seen by all seats
18. Circular shape for bench-style seating around an open space for professor
19. Modified u-shaped bench arrangement, with the opening providing enough space to accommodate ADA standards
20. Have four projectors on the roof that can be displayed onto screens or onto mirrors for hologram-like effects
21. Have the benches overhand the center area to provide space for backpacks or personal items underneath them
22. Fold out benches that hang over the side to provide as much inner space as possible
23. Ackerman steering wheels to allow for easy towing
24. Have overhanging walls that can be pushed out into multiple positions, one for keeping the inside safe, one for providing protection from rain, one for opening the space to nature completely
25. Have pull down smartboard for dual projection and whiteboard capabilities

26. Pull up tabling that can be released with a handle, spaced appropriately from inner bench dimensions and folding back towards the students
27. A pull-over sleeve (like a car cover) to protect the devices during storage
28. Have the device be a compact cube that can extend upwards with a projector and then balloon outwards from that as a weather shield/projector screen
29. Display screen for projector fans out sideways like a peacock's feathers
30. If privacy is required, have pull down shades on each side of the roof
31. Rotating seating arrangements so the class can face outwards to see examples
32. Display table can be pulled up from the center of the device to hold objects presenter brings and/or provide focal point for hologram to project onto
33. Have permanent walls that have grooved benches that can be pulled down to provide seating or put away to provide space
34. Have the presenting and seating space raised above the ground to provide storage space underneath the platform for items or power supplies
35. Using a golf cart itself or chassis to give the classroom mobility
36. Setting the classroom on a towable trailer and put all the things needed for standard class setting
37. Using a land drone like mechanism to autonomously transport the room from location to location
38. Using a floatation device on each side of the classroom, can make it travel on land and in water
39. For a military meeting room, tracks can be adaptive for traveling over rough rugged terrain
40. Using solar panels to power the electronics of the classroom

41. Make the structure out of lightweight materials that can be airlifted by helicopter during emergency situations (natural disasters)
42. The classroom can be mobile by flying drone
43. Classroom is foldable parts to make it more compact and portable
44. Rearranging the inside of a U-Haul like vehicle
45. Using a bus rearranging the inside so that it has all the media and teaching needs of a classroom
46. The roof of the bus or U-Haul vehicle can raise out or open to be more open to the environment
47. Use off road tires for increased mobility for different terrains
48. Delivery system like the public scooters
49. Canopy style setup
50. An extra padded mobile vehicle where the extra padding are components that will move into place acting as the seats and structural support for technology
51. Holographic 3D projection through a portable cannister
52. A large enough 3D projection using optically enhanced reflective material for projections
53. A walk-in tunnel where along the walls the lesson is projected, and the wall is touch screen
54. Have a box where a projector on the inside produces images onto the transparent side walls of the box for the audience to view
55. Rolling patio like rolling circular table stations, when deployed it stretches a netting with a pole in the middle for support to cover the classroom area
56. A rapid deployment tent with technology preinstalled in the walls and modular seats

57. Foldable structure centered around a board with optical properties only seen by the designated people wearing glasses
58. Portable floor setup that can fly autonomously and has technology and media on deck
59. Foldable classroom that fold into a box so it can be towed with a lift
60. Portable concert speaker that also transforms into an interactive touch screen tv
61. Have a projector place in a box like a mirror house at the fair but the mirrors are lens with various reflective and refractive properties
62. The walls can drop down after movement to provide an extra braking mechanism for the wheels (boxing in the wheels so they cannot go further)
63. Projectors are set up like a planetarium to provide a more complete image and 360-degree views of the subject matter
64. A car where when the trunk opens it expands into about a 10 ft tall interactive wall and the doors are modular components that can be used as benches too
65. Vr headsets where basically there is an administrator headset able to directly control what the class headsets see
66. Touch screen media displays stacked in a pyramidal scheme placed in the center of a circle of the audience with voting screens on the back of each chair
67. Food truck style van that has an Artificial intelligence system to identify writing on the outside of the walls of the van, and the people on the inside hand out tools for experiment-like demonstrations such as rapid design competition and interactive group work
68. Install device that turns any surface into a touch screen
69. Include large umbrella to cover from rain
70. Provide plastic cover for all electronics to avoid damage from humidity

71. Provide power outlet to charge phones and laptops
72. Include some speakers for showcasing videos with sound
73. Neon dim lighting across edges for nighttime meetings
74. cup/bottle holders to avoid spilling accidents
75. Comfortable seating with small fold-out table
76. Make the seats out of a waterproof material or something easy to clean
77. Seatbelts
78. Illumination for nighttime or foggy weather meetings
79. Remote control for volume and slideshows on projector
80. Heating system for cold weather
81. A sort of wall for when more privacy is required or when the outside is too noisy or sunny
82. Include a trash receptacle inside the device, which can be covered when needed
83. Utilize GPS tracking devices and send that signal back to the app for the device owner and the renter
84. Track location using localization techniques through motorized motion and the initial x and y coordinates
85. Use wheel braking mechanisms utilized on shopping carts to have wheels locked while in storage, provide a passcode to the users so they can utilize the cart for a specified time
86. Connect the device with nature through allowing for benches supported by one side and the other supported by a tree or natural landmark
87. Provide autonomous capabilities for specific locations, have the location be set by the user and the user must be within a specific range before the device will begin its motion to promote safety

88. Have a driver's seat portion to allow for the vehicle to be steered/driven, this area will double as a lecturer's seat
89. When registering to reserve the classroom, have needed documents uploaded to the website and automatically shared on the screen
90. Have the rechargeable battery be able to charge while properly located in its parking spot through electromagnetic fields
91. Video recording capabilities to monitor usage of devices and to connect with the initial sign up link so that other participants may listen in
92. Instead of a big table, individual tables come up from the individual seats.
93. Record and stream the sessions to invitees, automatically send to the users once the meeting/class is over.
94. Individual stools/seats in the given preferred shape.
95. Remote control that oversees the device's functionalities.
96. Customer service that oversees the device delivery and pick-up.
97. Table at the center of the device is comprised of small shelves that store components the users might need such as pointer, markers, chargers, and pop up classroom instructions.
98. Mini fans included if weather is stagnant.
99. Plastic covers fall from the sides of the umbrella, top of the device so that users don't get wet in case of rain.
100. Remote control to drive the device rather than a driver; no driver's seat will allow more space for the classroom.

Appendix D: Operations Manual

Overview

The PUC (PUC) is a device that creates a new campus experience. The device provides a collaborative environment that is nomadic and has the capability of being ordered online. The product allows for educational instruction outside of the standard classroom setting. It enables a comfortable interaction between professors and students, faculty, and classmates. The PUC includes all the necessary tools and classroom features so that lectures, meetings, and conversations are pleasant enough for its users.

Components and Modules Description

This section lists all the device components and their respective descriptions. Relevant information is provided on function and design of the components, as well as their intended purpose.

1. Roof

The length of the roof is 66 inches long.With the shaded parts added, it is 114 inches long with a width of 32 inches. The roof is intended to provide shelter for the device components and the user that is on the device.

2. Roof Legs

The legs support the roof to be a height of 6 foot 5 inches above the base of the cart. They also connect the roof to the cart.

3. Cart

The cart itself, which holds all the PUC components, is 5.617 feet in length, 2.279 feet in height, and 2.292 feet wide. It includes a gate that is magnetically coupled to the main frame.

This will prevent the gate from moving from its desired place. The cart also holds three junction boxes, each holding different electrical sub-components of the PUC.

4. Media Modules

4.1. Speaker: The speaker that was chosen was the SONOS Bar. The speaker is mounted on the rear wall to be easily accessed by the user. It has bluetooth capabilities as well as wired features as well such as aux cord capabilities.

4.2. Microphone: The microphone would be used with the speakers in the event there is a crowd, background noise, or if someone is soft spoken. Simply plug in the mic into the speakers and turn the devices on they are ready to use.

4.3. Monitor: The monitor used for this design would be the Samsung 32 inch Smart HDTV. It would operate the same way a normal TV would, with wifi capabilities. For a complete understanding one should consult the manual that is provided with the TV.

4.4. Monitor Mount: The mount is secured to the AV cabinet below it and is attached to the monitor to be raised and lowered by adjusting the neck according to the user’s needs. It's also able to slide the monitor forwards and backwards by adjusting the base.

4.5. Whiteboards: The whiteboards are attached to each side of the cart that will fold out when in use.

5. Electrical Components

5.1. Battery: powers the device and its components.

5.2. Arduino Nano 33: Information input from user

5.3. Raspberry Pi: Interprets user input into instruction for motors

5.4. Wifi Repeater: Allows convenient internet connectivity

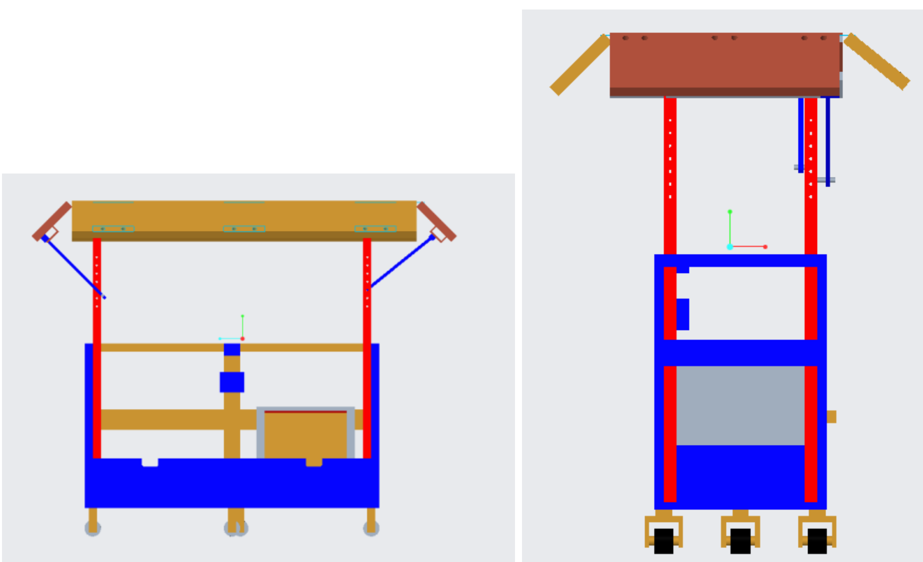
6. Motor

The PUC works with two different motors, each for a caster wheel. These are placed at the bottom of the cart. Each motor is controlled separately enabling zero point turning and they are powered by a 24V battery. There are caster wheels on the front and back of the RTC. It is equipped with a gate which lowers to allow easy access to the containers. To operate the RTC, a wireless controller is used to steer by varying the speed of each motor.

7. AV Cabinet

For further information on the cost and specific models brought by this team, please refer to our Bill of Materials. Further information on the costs and specific models bought by the team who designed the cart can be found here beginning on page 74.

Integration of Components



(a) (b)

Figure 14 *(a) Frontal view of the PUC, (b) side view of the PUC.*

Media modules are attached around the perimeter of the cart. On the front side of the cart, the monitor is attached to the mount on the inside part of the cart and to the side will be a speaker attached to the speaker mount. Make sure that the mounts are securely attached to the cart before attaching the monitor and speaker. On the sides will be the white boards, connected to the cart with a cylindrical revolute joint. The cabinet will be placed in the side space of the cart on the same side as the monitor. On the side of the cabinet facing the power supply, there should be a circular cavity big enough for wiring to pass through; providing a connection for the power supply to the DC-AC inverter and to power the electronics on board that requires a plug. The battery housing compartment should contain the power supply and wheel motors responsible for transportation. In future iterations it would seem convenient to place all essential power supplying elements such as the inverter into the middle housing compartment.

The roof legs are fitted inside the perimeter of the cart and attached to the sides via connecting bolts.

Electronic components are inside the junction boxes. The boxes are labeled J1, J2, J3. They hold the operation controls that provide power to the control system, the battery fuel gauge display, and the circuit breaker; the control system including the motor controller (Cytron SmartDriveDuo) and the ESP32; and the wireless charger, the motor and battery connections, respectively. Refer to figure 2 for illustration.

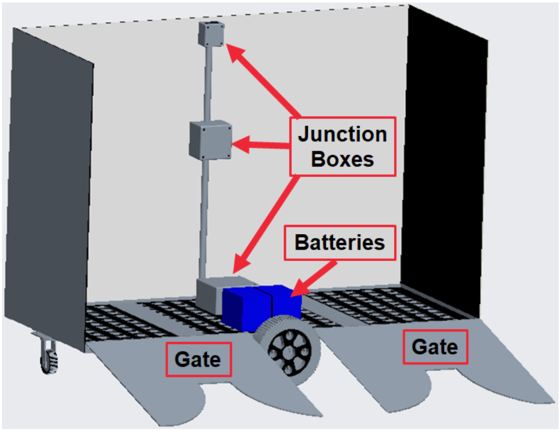


Figure 15 *3D rendering of the cart and its components*

Pseudo Code

```
While PowerOn== TRUE
{
if forward button == 1

     Roll both wheels forward;

if right button == 1
{
     Roll left wheels forward;
     Roll right wheels backward;
}
if left button == 1
{
     Roll right wheels forward;
     Roll left wheels backward;
}
if back button == 1

     Roll both wheels backward;
if Stop==1
     Don't move;
}
```

Operation:

- **To Navigate**

Using the phone app, the users will have a power button, and a basic directional pad for controlling the movement of the cart. In order for the cart to move, the power button on the physical cart (located on the highest junction box) must first be pressed. To have the cart move forward (in relation to the front of the cart) press the forward/up arrow. To have the cart move backward (in relation to the front of the cart) press the back/down arrow. To have the cart turn its front end left, press the left arrow, and to have the front end of the cart turn right, press the right arrow. To engage the breaks on the cart without powering the system off, press the middle button.

- **To Set Up for Instruction**

The roofing component should start at a stationary height of 6 feet 5 inches. If one would like to increase the height of the roof, you should remove the screws or pin connecting the roofing to the body of the cart, raise the roof to the desired height based on the pin holes provided, then place the screws back into the poles and secure them. To open the shading for the sides of the roof, simply raise each end by extending the shafts connecting the folding section of the roof to the body then tighten the wing nut in place to prevent it from closing in.

Disengage the gate from the lower junction box. This will require an initial large amount of force, but that is just to disengage the gate from the magnet. Once the gate is lowered, step onto the cart carefully by stepping over the gate to enter.

Turn on the media devices that will be in use (i.e. monitor, speaker, and microphone) while standing on the cart. These devices can be turned on how they typically

- **To Instruct Students**

There are many ways to utilize the vehicle for instruction. Below we will detail the recommended method.

Instructor is to stand upon the cart once its set up is complete. The instructor will be facing out towards the students, who may be situated in front of and to the sides of the professor on the ground. During typical instruction, the monitor can be utilized to display instructional material. As the monitor is a smart TV, it allows the user to bluetooth their screen onto the device or utilize an HDMI cord. Students are recommended to be to the front of the device when utilizing the monitor. When breaking the students into groups, the sides of the carts are most optimal as it provides the students with a space to jot their ideas. The instructor can feel free to move around the cart at this time to examine what is occurring and facilitate learning. It is recommended to close the gate of the cart when not intending to stand on the platform.

The speaker and microphone are provided for convenience, especially for soft-spoken professors or for when the PUC is used in a noisy environment. The monitor can also produce auditory sound, but should not be connected with the speaker.

- **To Break Down after Instruction**

All devices should be powered down upon completion of instruction, with the audio of the monitor being muted as well. Return all media options to their original state (i.e. wipe off the dry erase boards and place everything back in the drawers they were found in). Place the gate into its engaged position.

Fold the roofing components back down to allow for clearance during navigation. If the roof legs were lowered, please return them to their extended height. Navigate the cart back to its desired location based upon the instructions found in “To Navigate.” Turn off the vehicle using the power button.

Troubleshooting

If the device does not work as the manual instructs, please refer to this guide to solve the issue.

- Media device is not turning on
    - Make sure that the power is properly connect
    - Check and see if the there is power being supplied to the inverter
    - See if the battery is charged
- Roofing component is not stable
    - Tighten the bolts on the roof legs to the body of the cart itself
    - Make sure everything is in its proper place and not damaged
- Roofing folds are not going down
    - Loosen the wing nut on the shaft holding the roof up
    - Possible lubrication needed
    - Clear anything obstructing it
- Device is not in motion
    - Make sure the battery for the motors are fully charged as well as the remote controlling them
    - Make sure there is nothing obstructing the wheels or the cart itself
- Gate not opening
    - The magnet holding the gate up is strong so applying more force may be necessary
    - May need lubrication at the hinges

Work to Be Done

The basic frame of the cart is completed but converting it into the PUC is not completed. The batteries need to be replaced, since the current batteries do not have enough power due to extended time of disuse. The code is complete besides the aspects regarding connecting the hardware. Once hardware connection is completed, the code should be troubleshooted and fully implemented into the system. Due to the current situation, some of the components needed had their orders canceled (such as AV Cabinet, new batteries, white boards, mic), with a full list being defined within the BOM. Some of these components can still be purchased through personal funds and the BOM will be updated accordingly. The basic structure of the device is complete, though, the media devices just currently do not have a power supply nor are they attached to the PUC.

Appendix E: Software

The code used for the Arduino is based around taking digital readings of different parts of a circuit. The circuit involves 2 sets of 2 buttons apiece. These buttons are wired in a way that when one is pressed, the Arduino will read a different measurement than it will if the other is pressed. Based on these measurements, we can define states that will produce a different value to be transmitted via Bluetooth. The code also uses the builtin Bluetooth capability of the Arduino Nano 33 IoT, and its appropriate library, ArduinoBLE, to have the Arduino act as a peripheral that the Raspberry Pi can read values from.

The Arduino Code is the following:

```
#include <ArduinoBLE.h>

//const int outPin = 13; // Analog output pin that the LED is attached to

BLEService controlService("19B10000-E8F2-537E-4F6C-D104768A1214"); // BLE
control Service

BLEByteCharacteristic controlCharacteristic("19B10001-E8F2-537E-4F6C-
D104768A1214", BLERead);

void setup() {
  Serial.begin(9600);       // initialize serial communications at 9600 bps
  while(!Serial);
 // pinMode(outPin, OUTPUT);  // set pin 13 as an output


if (!BLE.begin())
  {
    Serial.println("starting BLE failed!");

    while (1);
  }
BLE.setLocalName("Controller");
BLE.setAdvertisedService(controlService);

controlService.addCharacteristic(controlCharacteristic);
BLE.addService(controlService);

controlCharacteristic.writeValue(0);

BLE.advertise();

Serial.println("BLE Controller Peripheral");
}
```

```
// These constants won't change. They're used to give names to the pins used:
const int analogInPin1 = A5;
const int analogInPin2 = A6;///////////////
//sv stands for sensor value
int sv1 = 0;        // value read from the buttons
int sv2 = 0;
int state = 0;              // used for storing what button was pressed

void loop()
{
BLEDevice central = BLE.central();
  if (central) {
    Serial.print("Connected to central: ");
    Serial.println(central.address());
  }
  // print the results to the Serial Monitor:
  readSwitch();
  //Serial.print("Value1 = ");
  //Serial.println(sv1);
  //Serial.print("Value2 = ");
  //Serial.println(sv2);
  Serial.print("State = ");
  Serial.println(state);

//The below if statements (and the else) are not necessary for our project
//they are only there for testing an LED for trouble shooting

//  if (state == 0) {
//    digitalWrite(outPin, LOW);
//    readSwitch();
//  }
//
//  if (state == 1) {                        //turns the LED off if a
certain button is pressed
//    digitalWrite(outPin, HIGH);
//    delay(25);
//    digitalWrite(outPin, LOW);
//    delay(400);
//    readSwitch();                        //contuines to poll the switch
circuitry
//  }
//
//  if (state == 2) {                        //runs a program similar to the
blink schetch if a certain button is pressed
//    digitalWrite(outPin, HIGH);
//    readSwitch();
//  }
//
//  if (state == 3) {                        //creates the 2 flash sequence
of the LED and polls the switches between delays
//    digitalWrite(outPin, HIGH);
//    delay(250);
//    digitalWrite(outPin, LOW);
//    delay(250);
```

```
//    readSwitch();
//  }
//
//  if (state == 4) {                          //Creates the fast blink effect
and polls the switches after one cycle of the blink effect
//    digitalWrite(outPin, HIGH);
//    delay(50);
//    digitalWrite(outPin, LOW);
//    delay(50);
//    readSwitch();
//  }
//  else {  ///You get the idea... make a unique state
//    digitalWrite(outPin, HIGH);
//    delay(50);
//    digitalWrite(outPin, LOW);
//    delay(50);
//    readSwitch();
//  }
}

void readSwitch () {                                  //creates the function
to read the switch states
  sv1 = analogRead(analogInPin1);              //read the analog pin the
switches are connected to
  sv2 = analogRead(analogInPin2);   //sv stands for sensor value

//top left button pressed sv1 <= 100
//bottom left button pressed sv1 >= 750 && sv1 <= 850
//top right button pressed sv2 <= 100
//bottom right button pressed sv2 <= 550 && sv2 >= 450
//button not pressed svX >= 1000

//Stopped
  if (sv1 >= 1000 && sv2 >= 1000)
  {
    state = 0;
    controlCharacteristic.writeValue(0);
    delay(100);
  }
//Forward Only
  if (sv1 <= 100 && sv2 >= 1000) {       //if the analog reading is within a
certain range we know which button was pressed and set the state accordingly
    state = 1;
    controlCharacteristic.writeValue(1);
    delay(100);                                      //delay for debounce
purposes
  }
//Back Only
  if (sv1 >= 750 && sv1 <= 850 && sv2 >= 1000) {       //if the analog
reading is within a certain range we know which button was pressed and set
the state accordingly
    state = 2;
    controlCharacteristic.writeValue(2);
    delay(100);                                      //delay for debounce
purposes
  }
```

```
//Left Only
  if (sv2 <= 100 && sv1 >= 1000) {       //if the analog reading is within a
certain range we know which button was pressed and set the state accordingly
    state = 3;
    controlCharacteristic.writeValue(3);
    delay(100);                                       //delay for debounce
purposes
  }
//Right Only
  if (sv2 >= 450 && sv2 <= 550 && sv1 >= 1000) {        //if the analog
reading is within a certain range we know which button was pressed and set
the state accordingly
    state = 4;
    controlCharacteristic.writeValue(4);
    delay(100);                                       //delay for debounce
purposes
  }
  //Forward and Left
  if (sv1 <= 100 && sv2 <= 100) {        //if the analog reading is within a
certain range we know which button was pressed and set the state accordingly
    state = 5;
    controlCharacteristic.writeValue(5);
    delay(100);
  }
  //Forward and Right
  if (sv1 <= 100 && sv2 >= 450 && sv2 <= 550) {        //if the analog
reading is within a certain range we know which button was pressed and set
the state accordingly
    state = 6;
    controlCharacteristic.writeValue(6);
    delay(100);
  }
  //Back and Left
  if (sv1 >= 750 && sv1 <= 850 && sv2 <= 100) {        //if the analog
reading is within a certain range we know which button was pressed and set
the state accordingly
    state = 7;
    controlCharacteristic.writeValue(7);
    delay(100);
  }
  //Back and Right
  if (sv1 >= 750 && sv1 <= 850 && sv2 >= 450 && sv2 <= 550) {        //if the
analog reading is within a certain range we know which button was pressed and
set the state accordingly
    state = 8;
    controlCharacteristic.writeValue(8);
    delay(100);
  }
  delay(1);                                           //delay for timeing
purposes
}
```

The code for the Raspberry Pi includes attempts at communicating with the Arduino board via bluetooth, as well as a complete keyboard control module. This module will supply power to the GPIO pins based on key presses registered by the keyboard listener, as well as cease supplying it when no key is pressed. The Raspberry Pi is coded using Python3, and takes advantage of the pynput library to program the keyboard in combination with the GPIO pins. The module can be used by using the WASD keys as well as the arrow keys to generate the power output, as well as both the ESC and P keys to forcefully make the device come to a full stop and cease sending power to the motors.

The Raspberry Pi code is the following:

```
from signal import pause
import RPi.GPIO as GPIO
import time
import serial
import sys
from pynput.keyboard import Key,KeyCode,Listener

#
#ser=serial.Serial(port="/dev/tty1")
#print("name ", ser.name)
#print("bytesizse", ser.bytesize)
#print("timeout ", ser.timeout)
#print("readable? ", ser.readable())

#setup of pin numbers
Motor_A1 = 13 #forwards
Motor_A2 = 19 #backwards
Motor_B1 = 16 #strafe left
Motor_B2 = 24 #strafe right

GPIO.setmode(GPIO.BOARD)
GPIO.setwarnings(False)
GPIO.setup(Motor_A1, GPIO.OUT)
GPIO.setup(Motor_A2, GPIO.OUT)
GPIO.setup(Motor_B1, GPIO.OUT)
GPIO.setup(Motor_B2, GPIO.OUT)

#functions for the movement functionality
def move_forward():
    print('going forward')
    GPIO.output(Motor_A1, 1)
    GPIO.output(Motor_A2, 0)
    GPIO.output(Motor_B1, 0)
    GPIO.output(Motor_B2, 0)
```

```
   # GPIO.cleanup()
def move_backward():
    print('going backwards')
    GPIO.output(Motor_A1, 0)
    GPIO.output(Motor_A2, 1)
    GPIO.output(Motor_B1, 0)
    GPIO.output(Motor_B2, 0)
   # GPIO.cleanup()
def turn_left():
    print('turning left')
    GPIO.output(Motor_A1, 0)
    GPIO.output(Motor_A2, 0)
    GPIO.output(Motor_B1, 1)
    GPIO.output(Motor_B2, 0)
    #GPIO.cleanup()
def turn_right():
    print('turning right')
    GPIO.output(Motor_A1, 0)
    GPIO.output(Motor_A2, 0)
    GPIO.output(Motor_B1, 0)
    GPIO.output(Motor_B2, 1)
   # GPIO.cleanup()
def UpLeft():
    print('forward left')
    GPIO.output(Motor_A1, 1)
    GPIO.output(Motor_A2, 0)
    GPIO.output(Motor_B1, 1)
    GPIO.output(Motor_B2, 0)
def UpRight():
    print('forward right')
    GPIO.output(Motor_A1, 1)
    GPIO.output(Motor_A2, 0)
    GPIO.output(Motor_B1, 0)
    GPIO.output(Motor_B2, 1)
def BackLeft():
    print('back left')
    GPIO.output(Motor_A1, 0)
    GPIO.output(Motor_A2, 1)
    GPIO.output(Motor_B1, 1)
    GPIO.output(Motor_B2, 0)
def BackRight():
    print('back right')
    GPIO.output(Motor_A1, 0)
    GPIO.output(Motor_A2, 1)
    GPIO.output(Motor_B1, 0)
    GPIO.output(Motor_B2, 1)
def engage_breaks():
    print('STOPPING')
    GPIO.output(Motor_A1, 0)
    GPIO.output(Motor_A2, 0)
    GPIO.output(Motor_B1, 0)
```

```
    GPIO.output(Motor_B2, 0)
  #  GPIO.cleanup()

#main while loop
while (True):
    COMMANDS = {
        frozenset([KeyCode(char='p')]): engage_breaks,
        frozenset([KeyCode(char='w')]): move_forward,
        frozenset([KeyCode(char='a')]): turn_left,
        frozenset([KeyCode(char='s')]): move_backward,
        frozenset([KeyCode(char='d')]): turn_right,
        frozenset([KeyCode(char='w'),KeyCode(char='s')]):
engage_breaks,
        frozenset([KeyCode(char='d'),KeyCode(char='a')]):
engage_breaks,
        frozenset([KeyCode(char='w'),KeyCode(char='a')]): UpLeft,
        frozenset([KeyCode(char='w'),KeyCode(char='d')]): UpRight,
        frozenset([KeyCode(char='s'),KeyCode(char='a')]): BackLeft,
        frozenset([KeyCode(char='s'),KeyCode(char='d')]): BackRight,
        frozenset([Key.esc]): engage_breaks,
        frozenset([Key.up]): move_forward,
        frozenset([Key.left]): turn_left,
        frozenset([Key.down]): move_backward,
        frozenset([Key.right]): turn_right,
        frozenset([Key.right , Key.left]): engage_breaks,
        frozenset([Key.down , Key.up]): engage_breaks,
        frozenset([Key.up , Key.left]): UpLeft,
        frozenset([Key.up , Key.right]): UpRight,
        frozenset([Key.down , Key.left]): BackLeft,
        frozenset([Key.down , Key.right]): BackRight,
    }
    current_keys = set()

    def on_press(key):
        current_keys.add(key)
        if frozenset(current_keys) in COMMANDS:
            COMMANDS[frozenset(current_keys)]()
    def on_release(key):
        engage_breaks()
        current_keys.remove(key)
    with Listener(on_press=on_press, on_release=on_release) as
listener:
        listener.join()

    #BLUETOOTH
    print(ser.read(1))

   # GPIO.cleanup(channel)
```

Appendix F: Website

The website snapshots are the following:

Figure 16 *Home page*

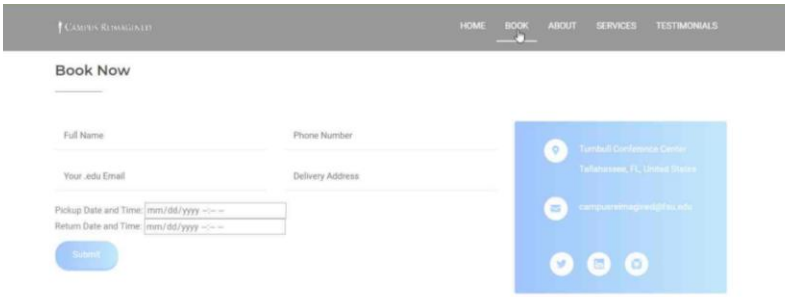


Figure 17 *Booking Section*

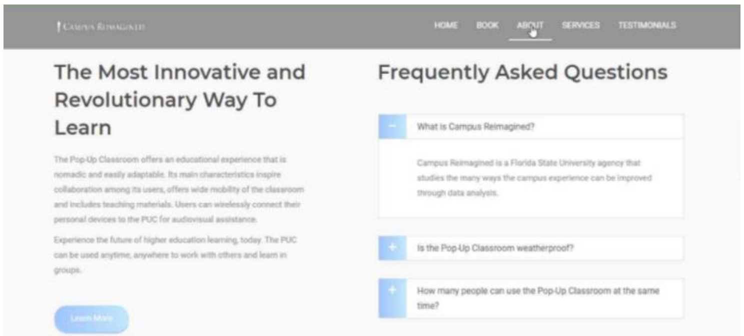


Figure 18 *About Section*

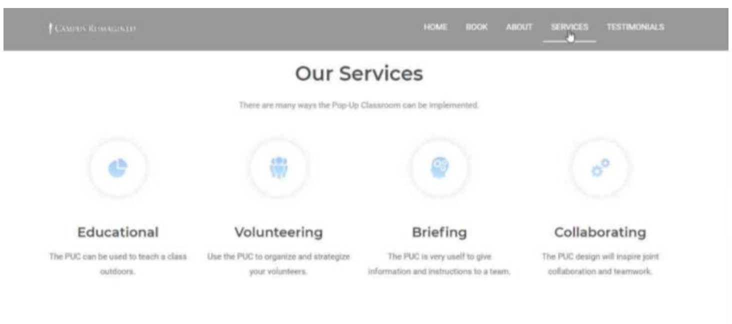


Figure 19 *Services Section*

Figure 20 *Testimonials Section*

The .html code for the website is the following:

```
<!doctype html>
```

```
<html class="no-js" lang="zxx">

<head>
    <meta charset="utf-8">
    <meta name="author" content="John Doe">
    <meta name="description" content="">
    <meta name="keywords" content="HTML,CSS,XML,JavaScript">
    <meta http-equiv="x-ua-compatible" content="ie=edge">
    <meta name="viewport" content="width=device-width, initial-
scale=1.0">
    <!-- Title -->
    <title>Pop-Up Classroom | CR</title>
    <!-- Place favicon.ico in the root directory -->
    <link rel="apple-touch-icon" href="images/CRWEBONLY.png">
    <link rel="shortcut icon" type="image/ico"
href="images/CRWEBONLY.png" />
    <!-- Plugin-CSS -->
    <link rel="stylesheet" href="css/bootstrap.min.css">
    <link rel="stylesheet" href="css/owl.carousel.min.css">
    <link rel="stylesheet" href="css/icofont.css">
    <link rel="stylesheet" href="css/magnific-popup.css">
    <link rel="stylesheet" href="css/animate.css">
    <!-- Main-Stylesheets -->
    <link rel="stylesheet" href="css/normalize.css">
    <link rel="stylesheet" href="style.css">
    <link rel="stylesheet" href="css/responsive.css">
    <script src="js/vendor/modernizr-2.8.3.min.js"></script>

    <!--[if lt IE 9]>
        <script
src="//oss.maxcdn.com/html5shiv/3.7.2/html5shiv.min.js"></script>
        <script
src="//oss.maxcdn.com/respond/1.4.2/respond.min.js"></script>
    <![endif]-->
</head>

<body class="site2" data-spy="scroll" data-target=".mainmenu-area">
    <!--Preloader-->
    <div class="preloader">
        <div class="spinner"></div>
    </div>

    <!-- Mainmenu-Area -->
    <nav class="navbar mainmenu-area" data-spy="affix" data-offset-
top="197">
        <div class="container">
            <div class="row">
                <div class="col-xs-12">
                    <div class="navbar-header smoth">
                        <a class="navbar-brand" href="#home-area"><img
src="images/logo.png" alt=""></a>
```

```
                    </div>
                    <div class="collapse navbar-collapse navbar-right"
id="mainmenu">
                        <ul class="nav navbar-nav primary-menu">
                            <li class="active"><a href="#home-
area">Home</a></li>
                            <li><a href="#book-area">Book</a></li>
                            <li><a href="#about-area">About</a></li>
                            <li><a href="#services-
area">Services</a></li>
                    <li><a href="#testimonials-
area">Testimonials</a></li>
                        </ul>
                    </div>
                </div>
            </div>
        </div>
    </nav>
    <!-- Mainmenu-Area-/ -->


    <!--Header-Area-->
    <header class="header-area overlay" id="home-area">
        <div class="vcenter">
            <div class="container">
                <div class="row">
                    <div class="col-xs-12 col-sm-10 col-sm-offset-1
col-md-8 col-md-offset-2 text-center">
                        <div class="header-text">
                            <div class="wow fadeInUp upper latter-
space" data-wow-delay="0.2s">AN IMPROVED LEARNING EXPERIENCE</div>
                            <h2 class="header-title wow fadeInUp
upper" data-wow-delay="0.4s">POP-UP CLASSROOM<span
class="dot"></span></h2>
                            <div class="wow fadeInUp" data-wow-
delay="0.7s">
                                <a href="#book-area" class="bttn bttn-
lg bttn-primary">Book Now</a>
                            </div>
                        </div>
                    </div>
                </div>
            </div>
        </div>
        <div class="smoth">
            <a href="#about-area" class="scrolldown"><i class="icofont
icofont-bubble-down"></i></a>
        </div>
    </header>
    <!--Header-Area-/-->
```

```
    <!-- Book Area -->
    <section id="book-area">
        <div class="section-padding">
            <div class="container">
                <div class="row">
                    <div class="col-xs-12">
                        <div class="page-title">
                            <h3 class="bar-title">Book Now</h3>
                        </div>
                    </div>
                </div>
                <div class="row">
                    <div class="col-xs-12 col-md-8">
                        <div class="contact-form">
                            <form action="process.php" id="contact-
form" method="POST">
                                <div class="form-double">
                                    <input type="text" id="form-name"
name="form-name" name="name" placeholder="Full Name"
required="required">
                                    <input type="number"
placeholder="Phone Number (xxx) xxx-xxxx">
                                </div>
                                <div class="form-double">
                                    <input type="email" id="form-
email" name="form-email" name="email" placeholder="Your .edu Email"
required="required">
                          <input type="text" id="form-address"
name="form-address" name="address" placeholder="Delivery Address"
required="required">
                                </div>
                      Pickup Date and Time:
                                    <input type="datetime-local"
id="form-pickupinfo" name="form-pickupinfo" name="pickupinfo"
placeholder="Pickup Information" required="required">
                      <p>
                      Return Date and Time:
                                    <input type="datetime-local"
id="form-returninfo" name="form-returninfo" name="returninfo"
placeholder="Return Information" required="required">
                      <p>
                            </form>
                    <button type="submit" form="contact-form"
value="Submit" class="bttn bttn-primary">Submit</button>
                        </div>
                    </div>
                    <div class="col-xs-12 col-md-4">
                        <div class="contact-info">
                            <ul class="info">
                                <li>
                                    <span class="info-icon">
```

```
                                        <i class="icofont icofont-
social-google-map"></i>
                                    </span>Turnbull Conference Center
<br />Tallahassee, FL, United States
                                </li>
                                <li>
                                    <span class="info-icon">
                                        <i class="icofont icofont-
envelope"></i>
                                    </span> campusreimagined@fsu.edu
                                </li>
                            </ul>
                            <div class="social-menu-2">
                                <a
href="https://twitter.com/campusreimagin1"><i class="icofont icofont-
social-twitter"></i></a>
                                <a
href="https://www.linkedin.com/school/campus-reimagined-florida-state-
university/"><i class="icofont icofont-social-linkedin"></i></a>
                                <a
href="https://www.instagram.com/campusreimagined"><i class="icofont
icofont-social-instagram"></i></a>
                            </div>
                        </div>
                    </div>
                </div>
            </div>
        </div>
    </section>
    <!-- Book Area / -->

    <!-- About-Area -->
    <section class="section-padding gray-bg" id="about-area">
        <div class="container">
            <div class="row">
                <div class="col-xs-12 col-sm-6 col-md-5">
                    <div class="page-title">
                        <h2 class="title wow fadeInUp">The Most
Innovative and Revolutionary Way To Learn</h2>
                        <div class="wow fadeInUp" data-wow-
delay="0.5s">
                            <p>The Pop-Up Classroom offers an
educational experience that is nomadic and easily adaptable. Its main
characteristics inspire collaboration among its users, offers wide
mobility of the classroom and includes teaching materials. Users can
wirelessly connect their personal devices to the PUC for audiovisual
assistance.</p>
                            <p>Experience the future of higher
education learning, today. The PUC can be used anytime, anywhere to
work with others and learn in groups.</p>
                        </div>
```

```
                    </div>
                    <div class="wow fadeInUp" data-wow-delay="0.7s">
                        <a
href="https://ww2.eng.famu.fsu.edu/me/senior_design/2020/team505/"
class="bttn bttn-primary" target="blank">Learn More</a>
                    </div>
                </div>
                <div class="hidden-xs col-sm-6 col-md-offset-1">
                    <div class="page-title">
                        <h2>Frequently Asked Questions</h2>
                    </div>
                    <div class="panel-group accordion1"
id="accordion">
                        <div class="panel">
                            <a data-toggle="collapse" data-
parent="#accordion" aria-expanded="true" href="#collapse1">What is
Campus Reimagined?</a>
                            <div id="collapse1" class="collapse in ">
                                <div class="text-body">Campus
Reimagined is a Florida State University agency that studies the many
ways the campus experience can be improved through data analysis.
                      </div>
                            </div>
                        </div>
                        <div class="panel">
                            <a data-toggle="collapse" data-
parent="#accordion" href="#collapse2">Is the Pop-Up Classroom
weatherproof?</a>
                            <div id="collapse2" class="collapse">
                                <div class="text-body">Yes, the Pop-Up
Classroom has all the design features necessary to make it resistant
to the effects of bad weather, especially rain.
                                </div>
                            </div>
                        </div>
                        <div class="panel">
                            <a data-toggle="collapse" data-
parent="#accordion" href="#collapse3">How many people can use the Pop-
Up Classroom at the same time?</a>
                            <div id="collapse3" class="collapse">
                                <div class="text-body">The Pop-Up
Classroom can be used by as many people as needed. Its individualistic
design allows for people to gather around it, while promoting
collaboration and innovation.
                                </div>
                            </div>
                        </div>
                    </div>
                </div>
            </div>
        </div>
```

```
    </section>
    <!-- About-Area / -->

    <!-- Services-Area  -->
    <section class="section-padding" id="services-area">
        <div class="container">
            <div class="row">
                <div class="col-xs-12 col-sm-8 col-sm-offset-2 col-md-
6 col-md-offset-3">
                    <div class="page-title text-center">
                        <h2 class="title">Our Services</h2>
                        <p>There are many ways the Pop-Up Classroom
can be implemented.</p>
                    </div>
                </div>
            </div>
            <div class="row process text-center">
                <div class="col-xs-12 col-sm-6 col-md-3">
                    <div class="single-process">
                        <div class="process-icon">
                            <i class="icofont icofont-pie"></i>
                        </div>
                        <h3>Educational</h3>
                        <p>The PUC can be used to teach a class
outdoors.</p>
                    </div>
                </div>
                <div class="col-xs-12 col-sm-6 col-md-3">
                    <div class="single-process">
                        <div class="process-icon">
                            <i class="icofont icofont-users-alt-
1"></i>
                        </div>
                        <h3>Volunteering</h3>
                        <p>Use the PUC to organize and strategize your
volunteers.</p>

                    </div>
                </div>
                <div class="col-xs-12 col-sm-6 col-md-3">
                    <div class="single-process">
                        <div class="process-icon">
                            <i class="icofont icofont-
brainstorming"></i>
                        </div>
                        <h3>Briefing</h3>
                        <p>The PUC is very uself to give information
and instructions to a team.</p>
                    </div>
                </div>
                <div class="col-xs-12 col-sm-6 col-md-3">
```

```
                    <div class="single-process">
                        <div class="process-icon">
                            <i class="icofont icofont-settings-
alt"></i>
                        </div>
                        <h3>Collaborating</h3>
                        <p>The PUC design will inspire joint
collaboration and teamwork.</p>
                    </div>
                </div>
            </div>
        </div>
    </section>
    <!-- Services-Area / -->

    <!-- Testimonials-Area / -->
    <section class="section-padding gray-bg" id="testimonials-area">
        <div class="container">
            <div class="row">
                <div class="col-xs-12 col-sm-8 col-sm-offset-2 col-md-
6 col-md-offset-3">
                    <div class="page-title text-center">
                        <h2 class="title">What Our Users Say</h2>
                        <p>The learning experience has been redefined
by the Pop-Up Classroom.</p>
                    </div>
                </div>
            </div>
            <div class="row">
                <div class="col-xs-12 col-md-10 col-md-offset-1">
                    <div class="testimonials">
                        <div class="single-testimonial text-center">
                            <div class="testimonial-text">
                                <em>Lorem ipsum dolor sit amet,
consectetur adipiscing elit. In ut sem a dui dignissim eleifend. In
dapibus iaculis urna non tempor. Phasellus facilisis sem nec.</em>
                            </div>
                            <h3>Samirao Boekeo</h3>
                            <h6>CEO, Classic Group</h6>
                            <div class="testimonial-img">
                                <img src="images/testimonial-1.png"
alt="">
                            </div>
                        </div>
                        <div class="single-testimonial text-center">
                            <div class="testimonial-text">
                                <em>Lorem ipsum dolor sit amet,
consectetur adipiscing elit. In ut sem a dui dignissim eleifend. In
dapibus iaculis urna non tempor. Phasellus facilisis sem nec.</em>
                            </div>
                            <h3>Samirao Boekeo</h3>
```

```
                            <h6>CEO, Classic Group</h6>
                            <div class="testimonial-img">
                                <img src="images/testimonial-2.png"
alt="">
                            </div>
                        </div>
                        <div class="single-testimonial text-center">
                            <div class="testimonial-text">
                                <em>Lorem ipsum dolor sit amet,
consectetur adipiscing elit. In ut sem a dui dignissim eleifend. In
dapibus iaculis urna non tempor. Phasellus facilisis sem nec.</em>
                            </div>
                            <h3>Samirao Boekeo</h3>
                            <h6>CEO, Classic Group</h6>
                            <div class="testimonial-img">
                                <img src="images/testimonial-1.png"
alt="">
                            </div>
                        </div>
                    </div>
                </div>
            </div>
        </div>
    </section>
    <!-- Testimonials-Area -->

    <!-- Footer-Area -->
    <footer class="footer-area">
        <div class="footer-top section-padding">
            <div class="container">
                <div class="row">
                    <div class="col-xs-12 col-md-3">
                        <div class="footer-text">
                            <h4 class="upper">Campus Reimagined</h4>
                            <p>A Place Of Becoming: where
understanding who you are shapes what you become.</p>
                            <div class="social-menu">
                                <a
href="https://twitter.com/campusreimagin1"><i class="icofont icofont-
social-twitter"></i></a>
                                <a
href="https://www.linkedin.com/school/campus-reimagined-florida-state-
university/"><i class="icofont icofont-social-linkedin"></i></a>
                                <a
href="https://www.instagram.com/campusreimagined"><i class="icofont
icofont-social-instagram"></i></a>
                            </div>
                        </div>
                    </div>
                    <div class="col-xs-6 col-md-2">
                        <div class="footer-single">
```

```
                            <h4 class="upper">Company</h4>
                            <ul>
                                <li><a
href="https://campusreimagined.fsu.edu/">CR Website</a></li>
                                <li><a
href="mailto:campusreimagined@fsu.edu">Email</a></li>
                            </ul>
                        </div>
                    </div>
                    <div class="col-xs-6 col-md-2">
                        <div class="footer-single">
                            <h4 class="upper">Resources</h4>
                            <ul>
                                <li><a
href="https://ww2.eng.famu.fsu.edu/me/senior_design/2020/team505/">Dev
eloper Website</a></li>
                                <li><a href="#book-area">Book
Now</a></li>
                            </ul>
                        </div>
                    </div>
                </div>
            </div>
        </div>
        <div class="footer-bottom">
            <div class="container">
                <div class="row">
                    <div class="col-xs-12">
                        <!-- Link back to Colorlib can't be removed.
Template is licensed under CC BY 3.0. -->
                        <p class="copyright">Copyright
&copy;<script>document.write(new Date().getFullYear());</script> All
rights reserved | This template is made with <i class="icofont
icofont-heart-alt" aria-hidden="true"></i> by <a
href="https://colorlib.com" target="_blank">Colorlib</a></p>
                        <!-- Link back to Colorlib can't be removed.
Template is licensed under CC BY 3.0. -->
                    </div>
                </div>
            </div>
        </div>
    </footer>
    <!-- Footer-Area / -->


    <!--Vendor-JS-->
    <script src="js/vendor/jquery-1.12.4.min.js"></script>
    <script src="js/vendor/bootstrap.min.js"></script>
    <!--Plugin-JS-->
    <script src="js/owl.carousel.min.js"></script>
    <script src="js/appear.js"></script>
```

```
    <script src="js/bars.js"></script>
    <script src="js/waypoints.min.js"></script>
    <script src="js/counterup.min.js"></script>
    <script src="js/easypiechart.min.js"></script>
    <script src="js/mixitup.min.js"></script>
    <script src="js/contact-form.js"></script>
    <script src="js/scrollUp.min.js"></script>
    <script src="js/magnific-popup.min.js"></script>
    <script src="js/wow.min.js"></script>
    <!--Main-active-JS-->
    <script src="js/main.js"></script>
    <script async defer
src="https://maps.googleapis.com/maps/api/js?key=AIzaSyDXZ3vJtdK6aKAEW
BovZFe4YKj1SGo9V20&callback=initMap"></script>
    <script src="js/maps.js"></script>
</body>

</html>
```

The .php booking form code is the following:

```
<?php
// Configure your Subject Prefix and Recipient here
$subjectPrefix = '[Contact via website]';
$emailTo       = '<vbernalma@gmail.com>';
$errors = array(); // array to hold validation errors
$data   = array(); // array to pass back data
if($_SERVER['REQUEST_METHOD'] === 'POST') {
    $name    = stripslashes(trim($_POST['name']));
    $email   = stripslashes(trim($_POST['email']));
    $address = stripslashes(trim($_POST['address']));
    $pickupinfo = stripslashes(trim($_POST['pickupinfo']));
    $returninfo = stripslashes(trim($_POST['returninfo']));
    if (empty($name)) {
        $errors['name'] = 'Name is required.';
    }
    if (!filter_var($email, FILTER_VALIDATE_EMAIL)) {
        $errors['email'] = 'Email is invalid.';
    }
    if (empty($address)) {
        $errors['address'] = 'Delivery address is required.';
    }
    if (empty($pickupinfo)) {
        $errors['pickupinfo'] = 'Pickup information is required.';
    }
    if (empty($returninfo)) {
        $errors['returninfo'] = 'Return information is required.';
    }
    // if there are any errors in our errors array, return a success
boolean or false
    if (!empty($errors)) {
```

```
        $data['success'] = false;
        $data['errors']  = $errors;
    } else {
        $subject = "$subjectPrefix";
        $body    = '
            <strong>Name: </strong>'.$name.'<br />
            <strong>Email: </strong>'.$email.'<br />
            <strong>Delivery Address: </strong>'.$address.'<br />
            <strong>Pickup Information: </strong>'.$pickupinfo.'<br />
            <strong>Return Information: </strong>'.$returninfo.'<br />
        ';
        $headers  = "MIME-Version: 1.1" . PHP_EOL;
        $headers .= "Content-type: text/html; charset=utf-8" .
PHP_EOL;
        $headers .= "Content-Transfer-Encoding: 8bit" . PHP_EOL;
        $headers .= "Date: " . date('r', $_SERVER['REQUEST_TIME']) .
PHP_EOL;
        $headers .= "Message-ID: <" . $_SERVER['REQUEST_TIME'] .
md5($_SERVER['REQUEST_TIME']) . '@' . $_SERVER['SERVER_NAME'] . '>' .
PHP_EOL;
        $headers .= "From: " . "=?UTF-8?B?".base64_encode($name)."?="
. "<$email>" . PHP_EOL;
        $headers .= "Return-Path: $emailTo" . PHP_EOL;
        $headers .= "Reply-To: $email" . PHP_EOL;
        $headers .= "X-Mailer: PHP/". phpversion() . PHP_EOL;
        $headers .= "X-Originating-IP: " . $_SERVER['SERVER_ADDR'] .
PHP_EOL;
        mail($emailTo, "=?utf-8?B?" . base64_encode($subject) . "?=",
$body, $headers);
        $data['success'] = true;
        $data['message'] = 'Congratulations. Your booking has been
sent successfully';
    }
    // return all our data to an AJAX call
    echo json_encode($data);
}
?>
```

Appendix G: Risk assessment

Safety Plan

Project information		
PUC		November 15, 2019
Name of Project		Date of submission
Team Member	Phone Number	e-mail
Valeria Bernal	(850)567-7379	vb15b@my.fsu.edu
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Michael Johnson	(850)384-3404	michael17.johnson@famu.edu
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Faculty mentor	Phone Number	e-mail
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I. Project description

Our design focuses on bringing an enjoyable, productive, and collaborative classroom experience outside. Through the process of generating several different ideas, our team eventually selected a design that was based upon a towable trailer. This design would perform excellently across multiple types of terrain, and various amounts of incline, as the mobility aspect is delivered by the vehicle that is towing the classroom. The design features bench seating around the perimeter of the unit, such that the “class” is facing inward toward each other. The middle of the unit will also have tables for the “students” to have workspace. The middle of the unit will also have a limited number of seating intended for an “instructor” to use. The front of the unit will feature a projector screen, powered by a battery where a user can connect their electronics to display to the “class”. The unit will also enable WI-FI connectivity through the use of a provided hotspot. The design will also feature an online portion so that PUC units can be reserved and ordered online.

II. Describe the steps for your project

Apply the shock-absorber to the trailer system.
Determine the measurements for the drawers and order them custom made, measure out an area to store the battery power.
Measure and trace out the necessary dimensions for covering the trailer, account for an opening at the base for the drawers.
Use a saw to cut out the material at the specified dimensions for covering the trailer and producing the seats, roof, and pillars.
Determine the pc pipe network needed to go through the cart for wires, secure it to the base floor of the cart.
Cut rows of openings for ventilation on the side where the battery will be located.
Affix the wood to the trailer using wood glue, wood screws, zip-ties, or whatever is needed for a secure connection.
Insert pillars for structural integrity between and around the drawer and battery area. Affix with wood glue.
Use wood screws to secure a hinge to the wood panel acting as the door to the battery.
Secure a velcro strip to the door and base frame to ensure a secure but removable fit.
Run the wires through the pc piping starting at the battery and ending before it exits the battery/drawer compartment.
Create the seating ledges around the edges of the trailer, secure them to the base frame using wood glue.
Test the security of the seats by adding increasing amounts of weight in the form of dumbbells.
Mill out a divot for the placement of the pillars around the edges of the trailer frame.
Secure the pillars with wood glue.
Test the strength of the pillars using pulling and pushing forces from the students. Have another student available to assist in case
a pillar falls over towards the student testing.
Affix the pc pipe to the insides of the pillars until it reaches the top.
Cut out and assemble the wood frame for the roofing on an elevated platform.
Lift the roofing platform the rest of the way upwards onto the pillars and secure using wood screws.

III. Given that many accidents result from an unexpected reaction or event, go back through the steps of the project and imagine what could go wrong to make what seems to be a safe and well-regulated process turn into one that could result in an accident. (See examples)

The biggest risks will come from the physical assembly of the PUC unit. Many power tools such as saws, drills, and screwdrivers will be vital in properly assembling the design. A careless worker could easily injure themselves while using a saw or any of the other power tools. The trailer will also be heavy and bulky. Carelessness could result in a worker getting caught under the trailer and potentially suffering a dangerous amount of weight to a part or all of his/her body. The electrical aspect of the PUC also poses a potential danger. Great care will need to be taken while working with the battery, and wiring different aspects of the unit together.

Electrical Aspects: There is always a risk of electrocution when dealing with electrical components.

Power Tools: Power tools come with the risk of cutting or impaling the users body if the are mishandled.

Hand Tools: Screw Drivers, Socket Wrenches, Hammers and other hand tools run the risk of injury similar to using power tools

Wood material: Splinters, being cut or bruised, head injuries

Wood glue: Glueing hands together and consuming glue are main concerns of glue users

Lifting the roof: Roof falling on someone, cuts buy edges of the roof

Trailer Usage: high speeds, can cause instability and lose control

Shock Absorber: Shocks falling off, hand injuries while assembling

IV. Perform online research to identify any accidents that have occurred using your materials, equipment or process. State how you could avoid having this hazardous situation arise in your project.

A plethora of examples with table saws and skill saws exist. The safest procedure to avoid an accident using these tools is to cut in a very controlled environment. This includes cutting on a very stable surface, making planned, deliberate cuts, using utmost caution to avoid putting any parts of the body in the path of the saw. Accidents involving electrical wiring are also very frequent. Avoiding accidents with electrical wiring includes: wearing protective gloves, wearing safety glasses, and having a fire suppression system nearby at all times when working with electrical systems. Hands and other parts of the body will be kept free from free-moving mechanical parts whenever possible.

V. For each identified hazard or "what if" situation noted above, describe one or more measures that will be taken to mitigate the hazard. (See examples of engineering controls, administrative controls, special work practices and PPE).

Electrical Aspects: Insulating non conductive clothing material will be worn to prevent electrical accidents

Power & Hand Tools: Proper eye, head, hand, and body protection clothing will be worn when using tools while also another group member is present

Wood material: Protective clothing and adequate tool station for wood cutting and related operations while also having another group member present

Wood glue: Protective hand gloves will be worn to prevent glue accidents

Lifting the roof: Strong and skilled personnel will be present for heavy lifting and other related tasks

Trailer Usage: There will warning label including max velocity and other pertinent performance specifications

Shock Absorber: Use the proper tools and be sure that the trailer used as a base is stationary when assembling the shocks

VI. Rewrite the project steps to include all safety measures taken for each step or combination of steps. Be specific (don't just state "be careful").

While wearing the proper safety attire, fix the vehicle into a stationary, safe and secure workable position.

Apply the shock-absorber to the trailer system.

Determine the measurements for the drawers and order them custom made, measure out an area to store the battery power.

Measure and trace out the necessary dimensions for covering the trailer, account for an opening at the base for the drawers.

Use a saw to cut out the material at the specified dimensions for covering the trailer and producing the seats, roof, and pillars.

Determine the pc pipe network needed to go through the cart for wires, secure it to the base floor of the cart.

Make sure the area of placement for the battery is open and no unintended objects will be in the way of cutting.

Cut rows of openings for ventilation on the side where the battery will be located.

Affix the wood to the trailer using wood glue, wood screws, zip-ties, or whatever is needed for a secure connection.

Insert pillars for structural integrity between and around the drawer and battery area. Affix with wood glue.

Use wood screws to secure a hinge to the wood panel acting as the door to the battery.

Secure a velcro strip to the door and base frame to ensure a secure but removable fit.

Make sure no electrically conductive material is worn

Run the wires through the pc piping starting at the battery and ending before it exits the battery/drawer compartment.

Create the seating ledges around the edges of the trailer, secure them to the base frame using wood glue.

Clear the area around the seating arrangement of debris before the beginning of testing.

Test the security of the seats by adding increasing amounts of weight in the form of dumbbells.

Make sure the proper equipment is on and the worker(s) are fully focused.

Mill out a divot for the placement of the pillars around the edges of the trailer frame.

Secure the pillars with wood glue. Have another student available to assist in case a pillar falls over towards the student testing.
Test the strength of the pillars using pulling and pushing forces from the students.
Affix the pc pipe to the insides of the pillars until it reaches the top.
Cut out and assemble the wood frame for the roofing on an elevated platform.
With the appropriate personnel lift the roofing platform the rest of the way upwards onto the pillars and secure using wood screws.

VIII. List emergency response contact information:

Call 911 for injuries, fires or other emergency situations

Call your department representative to report a facility concern

Name	Phone Number	Faculty or other COE emergency contact	Phone Number
Dr. Shayne McConomy	(850) 410-6624		
Dr. Jerris Hooker	(850)410-6463		

IX. Safety review signatures

Faculty Review update (required for project changes and as specified by faculty mentor)

Updated safety reviews should occur for the following reasons:

Faculty requires second review by this date:

Faculty requires discussion and possibly a new safety review BEFORE proceeding with step(s)

An accident or unexpected event has occurred (these must be reported to the faculty, who will decide if a new safety review should be performed.

Changes have been made to the project.

Team Member	Date	Faculty mentor	Date
Valeria Bernal	04/21/2020	Dr. Dhayne McConomy	04/21/2020
Kyle Jackey	04/21/2020	Dr. Jerris Hooker	04/21/2020
Yahdid James	04/21/2020		
Michael Johnson	04/21/2020		
Jean Patrick Roquebert	04/21/2020		
Daziyah Sullivan	04/21/2020		

Report all accidents and near misses to faculty mentor.