EEL 4911C/4915C, EML4551C/4552C
Electrical and Computer Senior Design, Mechanical Engineering Senior Design
Team 505: Pop-Up Classroom

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Evidence Manual

Table of Contents

Add Headings (Format > Paragraph styles) and they will appear in your table of contents.

Project Scope

Project Brief

Campus Reimagined (CRI) seeks to create a new campus experience through a pop-up classroom. 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.

Project Description

The purpose of this project is to design a nomadic classroom that is able to accommodate the key components of a learning environment. It should allow for educational instruction outside of the standard classroom setting.

Stakeholders

The Pop-Up Classroom 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 advisors 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 includes 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 allows for this list to adjusted and added to as it progresses.

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 in regards to customer needs.

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.

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 be include autonomous capabilities in the first iteration

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

Customer Needs

This project is defined by the interactions of customers with the product and how it may be integrated into the educational setting. With this in mind, 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.

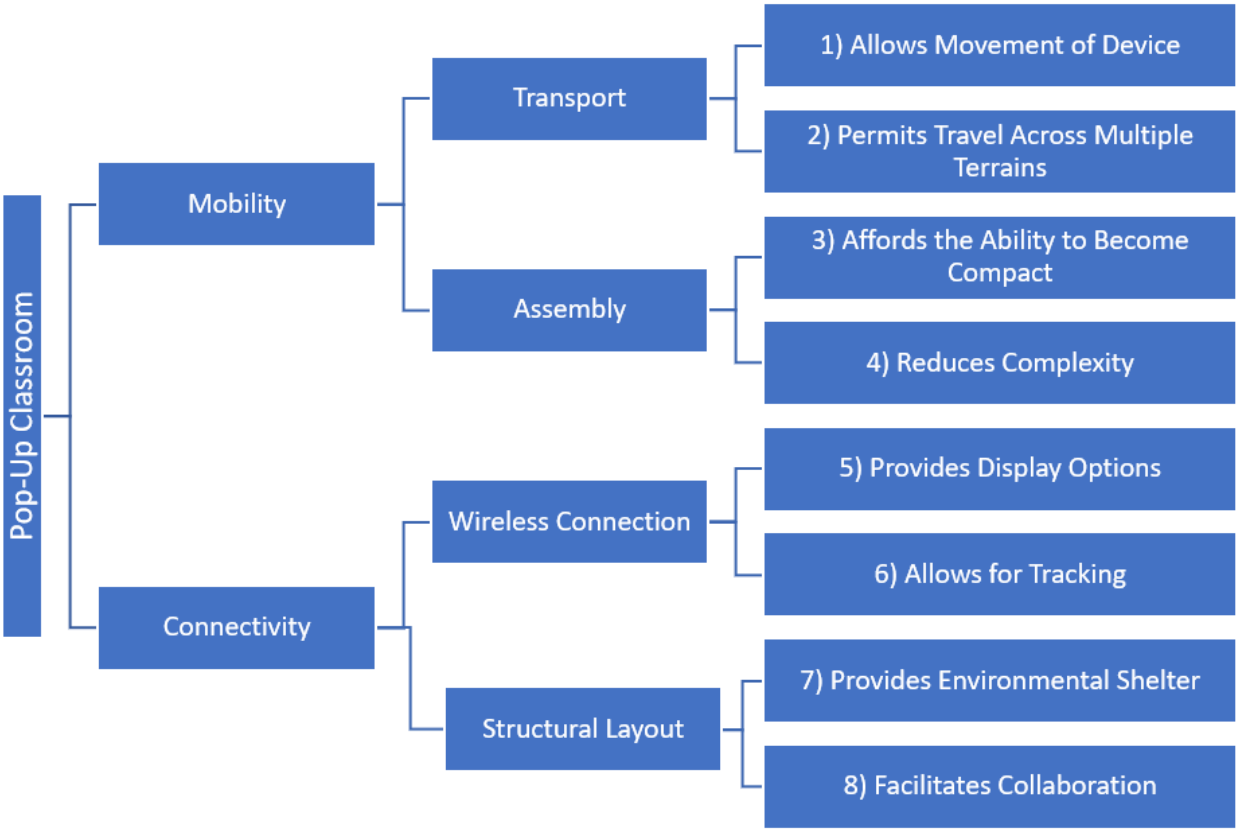
Question/Prompt	Customer Statement	Interpreted Need
Questions to the Sponsor		
As Stated in Project Brief	The popup classroom should provide a collaborative environment that is nomadic and has the capability of being ordered online	1. The layout provides the ability for collaborative input
		2. The product 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. Wifi	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 similar to 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 pop-up classroom aims to change the current dynamic y improving current issues and leaning on the current positives, with a particular 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.

Functional Decomposition

The objective of a function decomposition is to breakdown complex solutions into functional objectives similar to 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. 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.

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.

Targets and Metrics

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 needs we the basis to determine the project targets. The critical targets for the pop-up classroom 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.

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 pop-up classroom, 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 pop-up classroom 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 pop-up classroom 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 pop-up classroom 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. This standard rates will increase network capacity by adding broadcast subchannels and allowing more simultaneous data streams. We expect that the pop-up classroom 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 pop-up classroom'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 pop-up classroom. More specifically, the design priority is its connectivity feature because it will provide the collaboration opportunities the pop-up classroom 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.

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.

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	Collapsable 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

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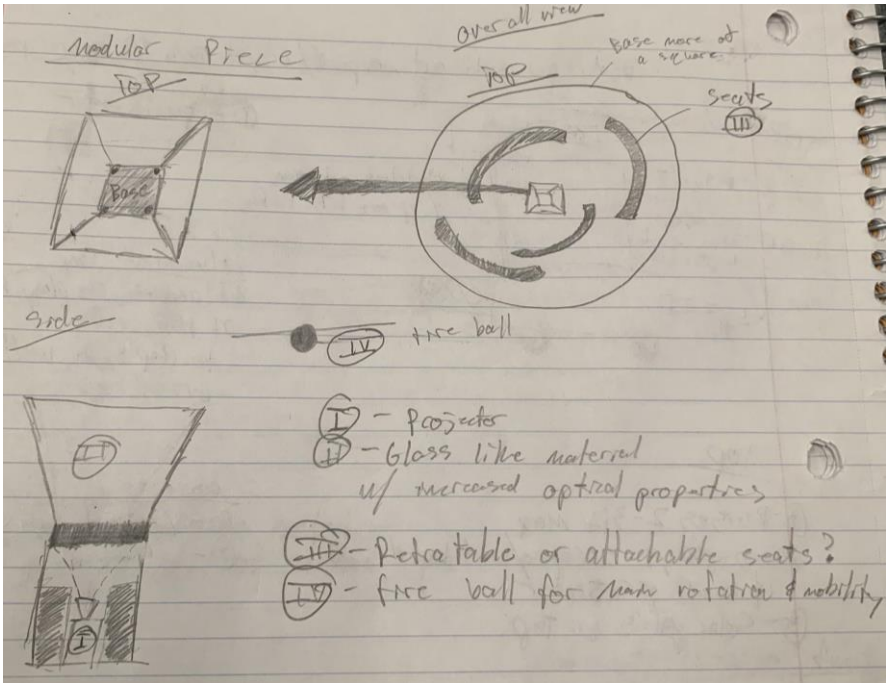
Utilizing the concepts determined through multiple brainstorming sessions and the morphological chart, we went on to compose complete concepts for the product. Fidelity for concepts was determined based on structural integrity, commitment to the functional requirements, assembly ability, and potential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

Medium Fidelity Designs

Design 1

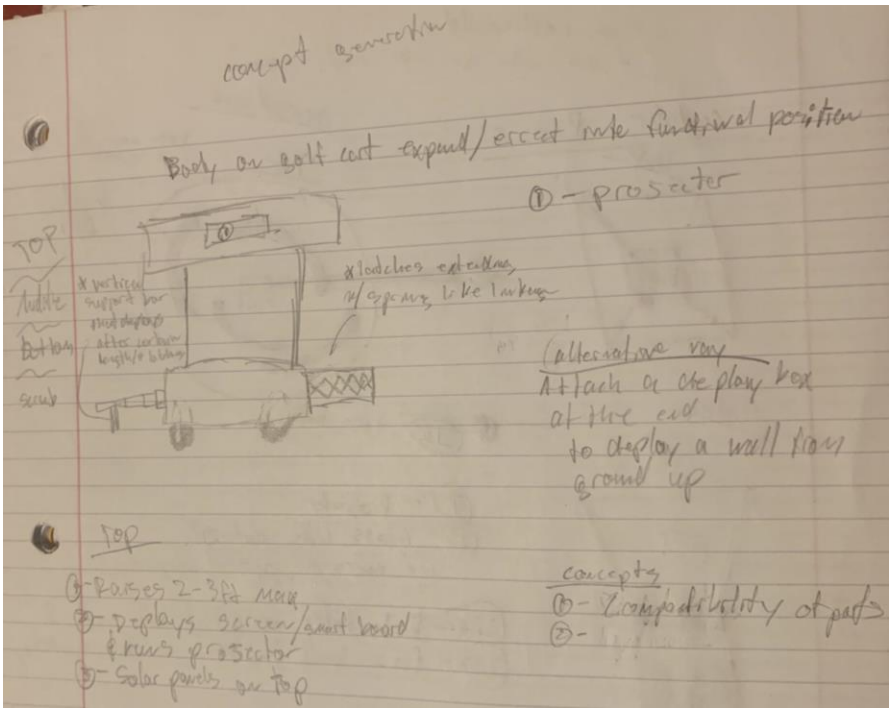
Design 1 is made up of three major parts; the floor, projector stand, and 3D projector. This design's main concepts of focus was collaboration and compactibility through modularity. The concept of influencing collaboration plays in hand with the floor functions, which is to come with retractable seats 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.



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 to have more than one media display for ease of viewing by larger audiences by providing options.

Design 2

Here in design II mobility and display devices are objective concepts engaged directly with this design. The Pop up classroom 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.

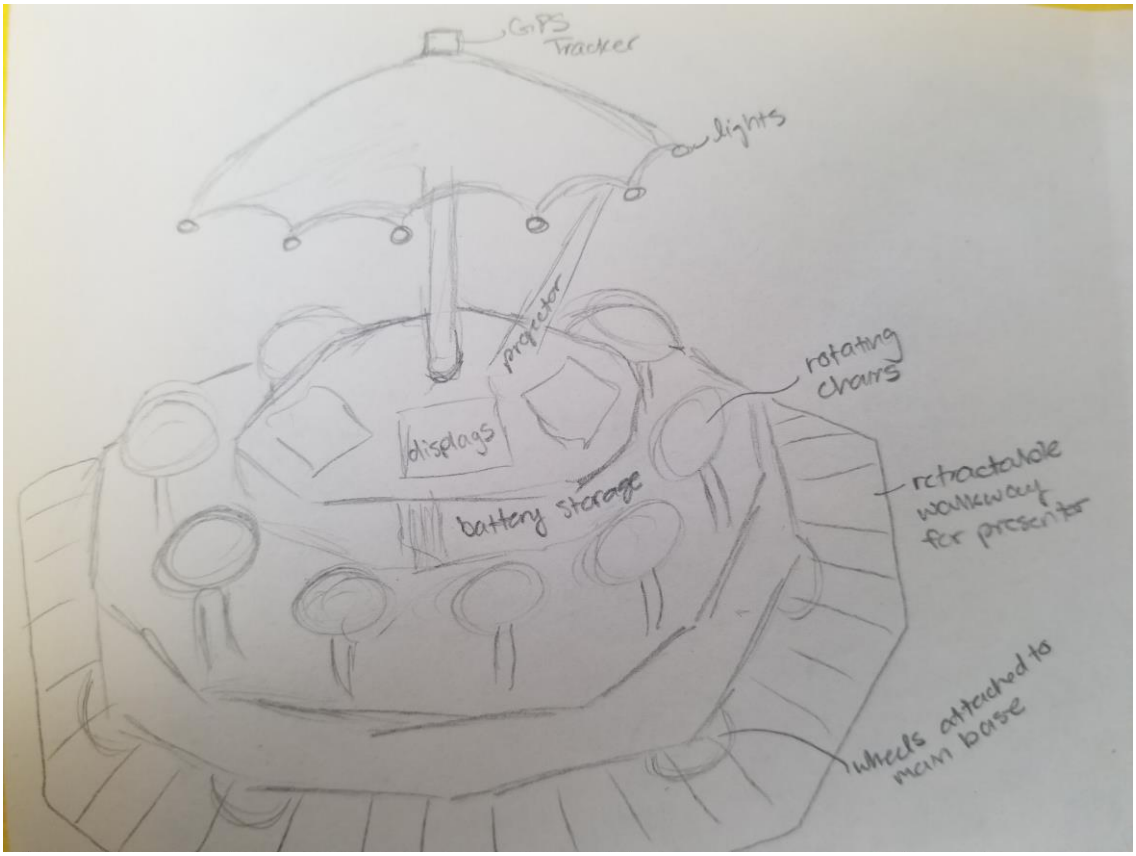


This would have been a high fidelity idea but the initial idea was based off the LG foldable tv but this technology is not available for commercial use yet; consequently, using multiple projectors for each side will take more resources which can be conserved through other design solutions. A weakness 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 Pop up classroom, more material leading to higher power requirement will be needed, which will ultimately surpass ideal weight parameters.

Design 3

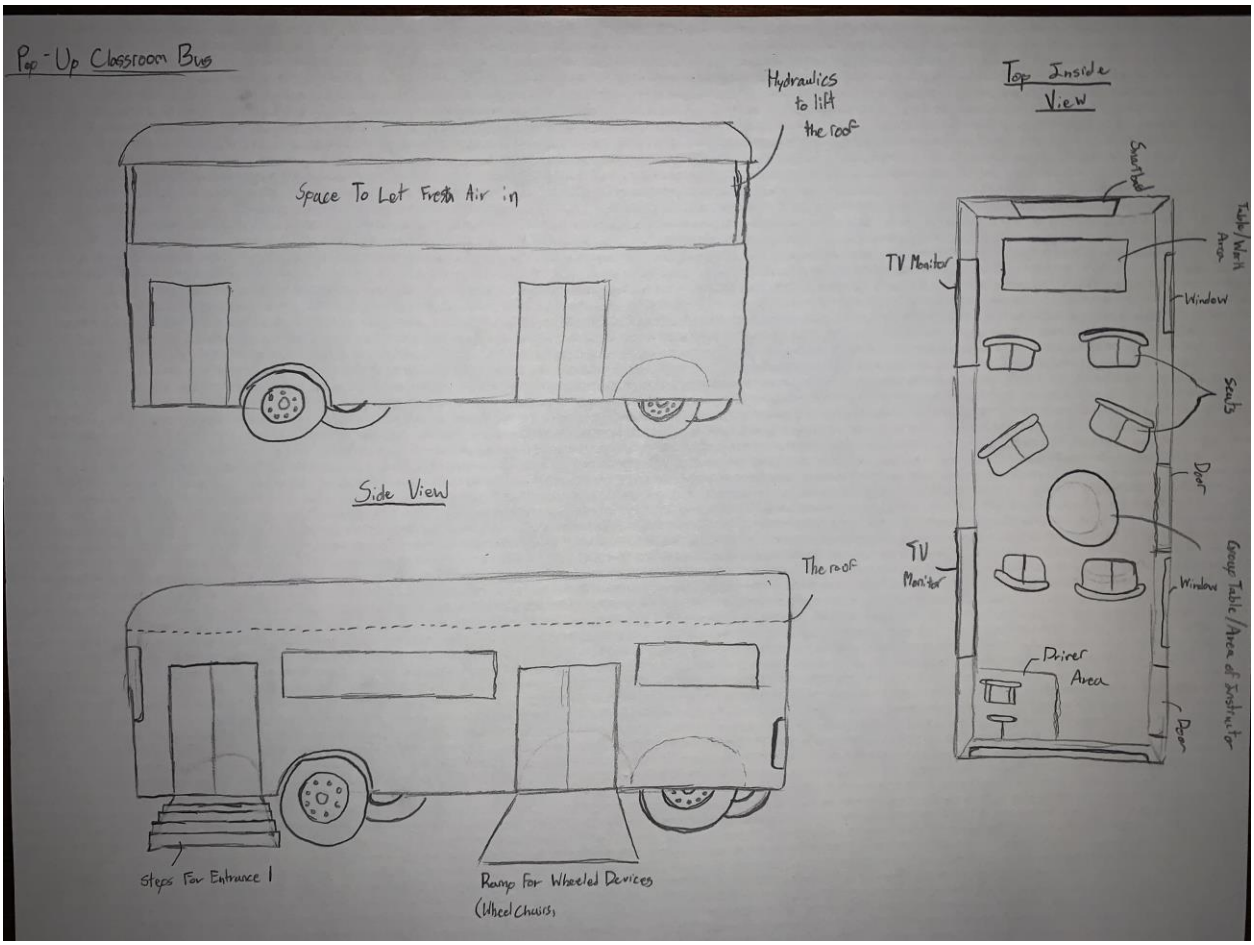
This design centers around a typical courtyard style table, while incorporating different teaching tools to ensure the methods of use are good. Projectors are located within the umbrella folds, stabilized by extra bars within the umbrella frame. This provides both display devices and protection from 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 is able to walk around the device on an elevated, grated platform that locks into an upper position during transportation. Not pictured is a handle bar that can be used to pull the device from place to place, which is located close to the wheels and has extending capabilities similar to 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 night time events).



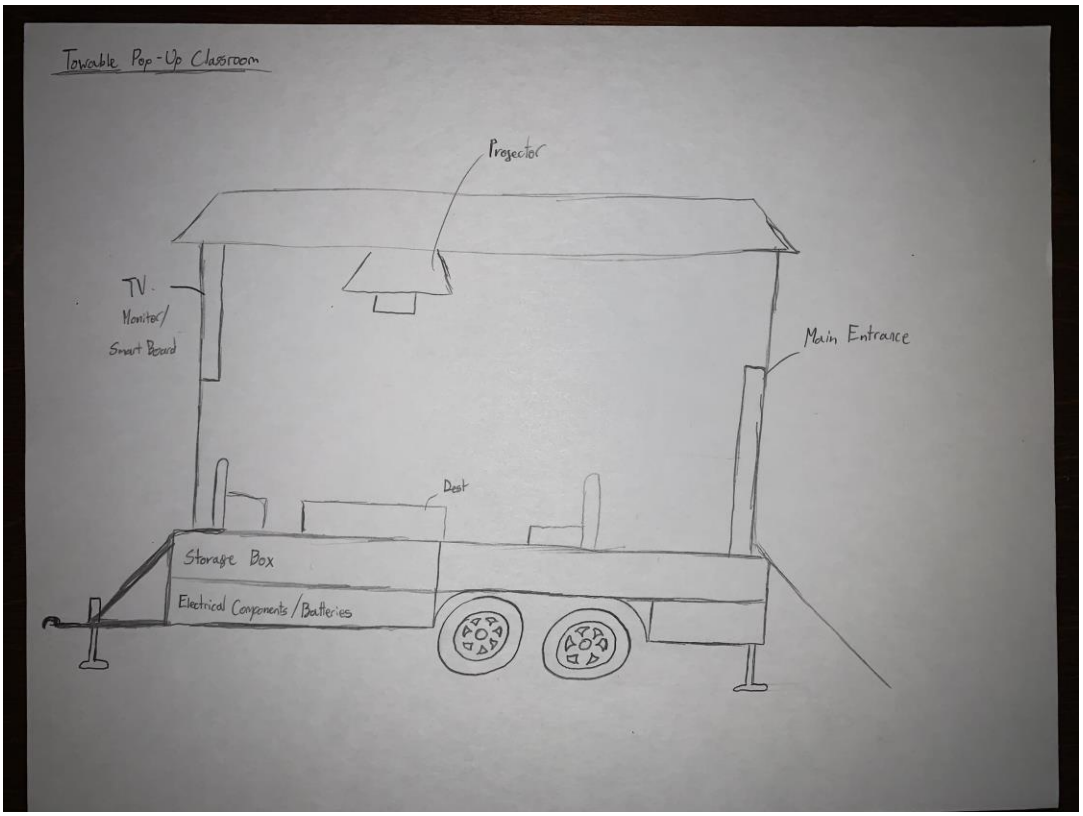
Design 3 was determined to be of medium fidelity due to potential sizing issues and the amount of moving parts. The components provide an opportunity for compactibility, but likely not within the metrics we had previously determined. The multiple moving parts bring up an issue with securability and safety 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.

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 are enough seating for at least 10 individuals and would have all of 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.

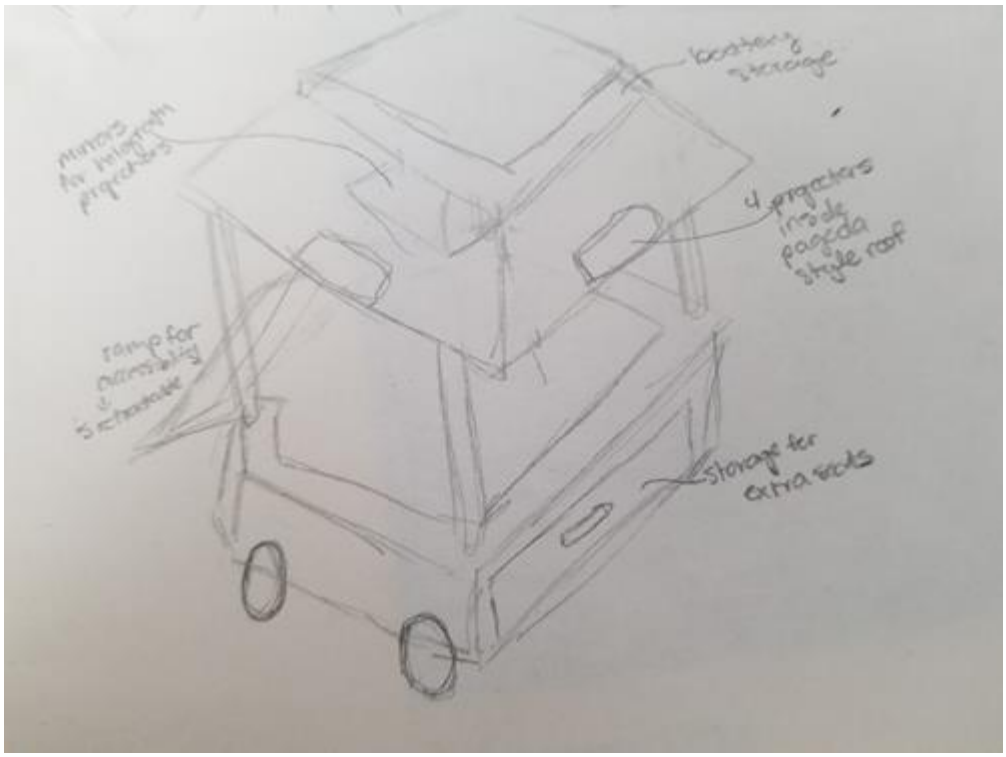
Design 5



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 of the storage for classroom items in storage boxes underneath. Below the storage boxes are the batteries and electrical components to supply power to all of 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.

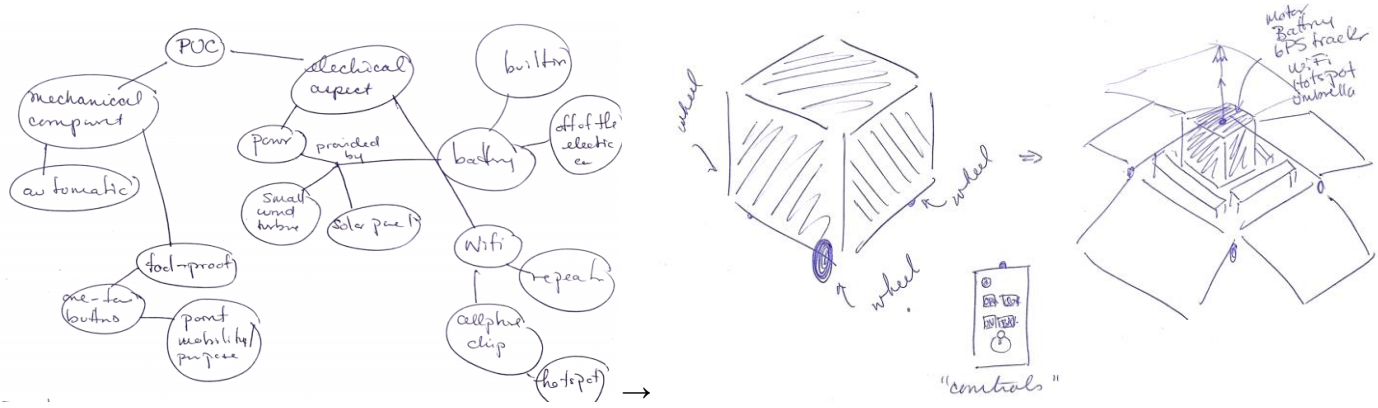
High Fidelity Designs

Design 1



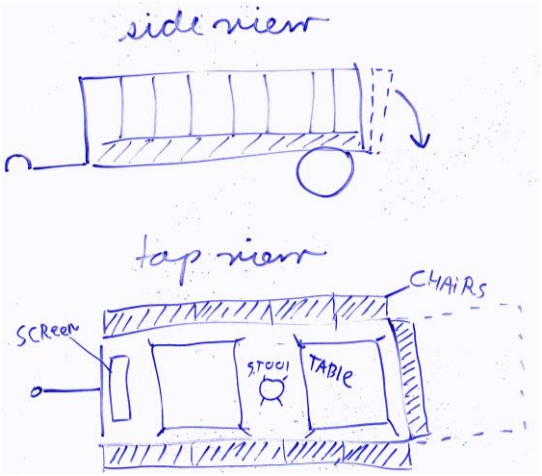
This design is a cart with a roof to protect from rain and block some sunlight. It includes some storage compartments for the seats, a ramp to allow wheelchair access, a battery storage compartment overhead to power all the electronics, and projectors pointing towards all four directions.

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 pop-up classroom will have. This includes (a) the mechanical aspect and (b) the electrical part. For (a), its 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 pop up classroom 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 rollable displays. The battery, GPS tracker, WiFi, electrical wiring, and motor are inside the table at the center of the cube.

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.

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.

Binary

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 of 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 similar to a checklist item when completed, but for the sake of bureaucracy of this project they will yield the simple result of yes or no.

House of Quality Chart

		Engineering Characteristics						
Improvement Direction			↑	↑			↑	↑
Units			lbs	#			m^3	kwH
Customer Requirements	**Importance Weight Factor**	**Wheels and brakes are present**	**Device weight tolerance**	**Movable components 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.

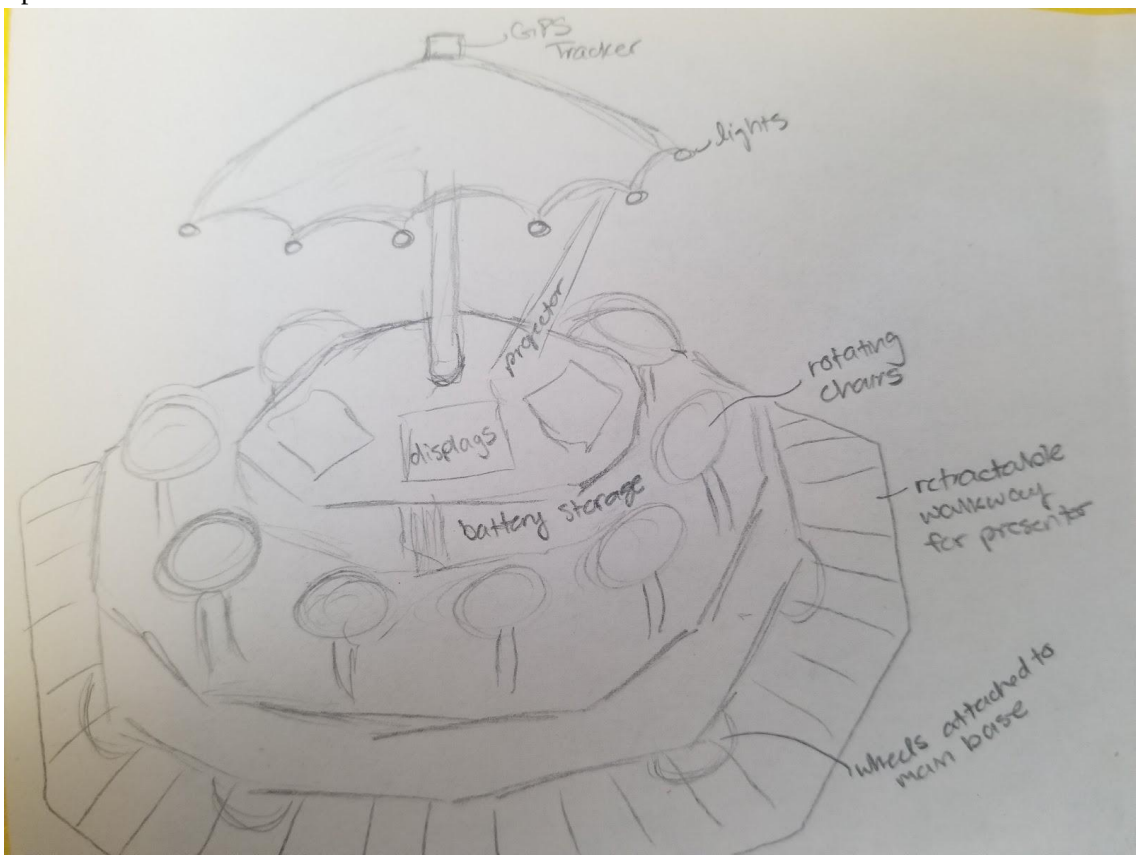
Initial Pugh Selection Chart

		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 became the datum concept.

Concept 3



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, intuitivity, and weight tolerancing. In reality 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 of relative inferiority.

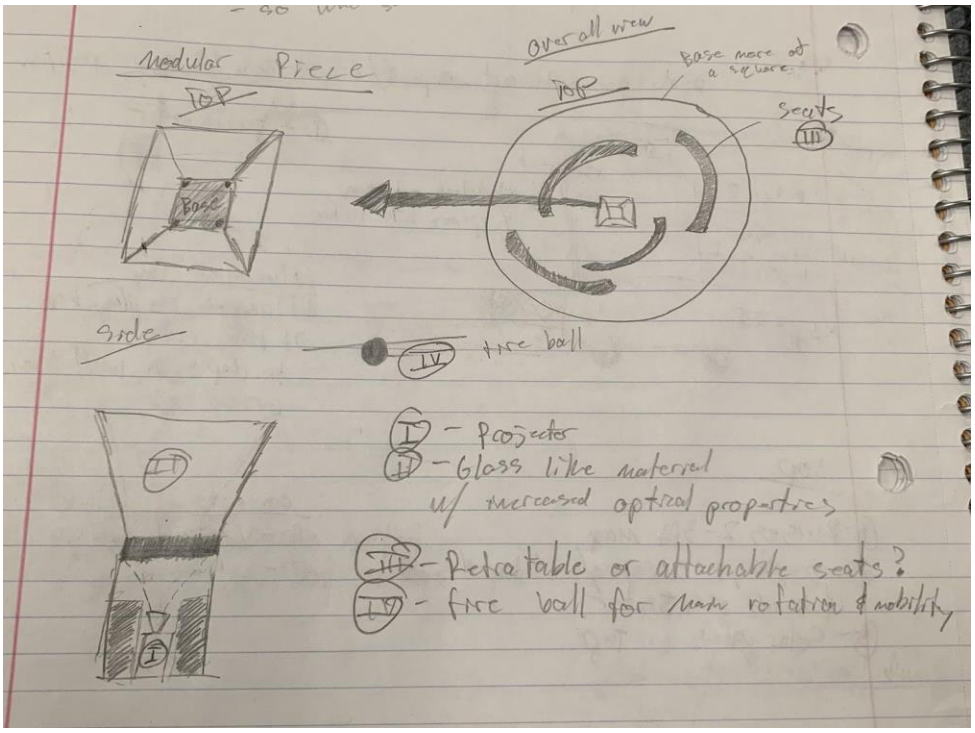
Second Pugh Selection Chart

		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 had the most amount 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.

Concept 1



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.

Third Pugh Selection Chart

		Concepts			
Selection Criteria	**Concept 1**	**5**	**6**	**7**	**8**

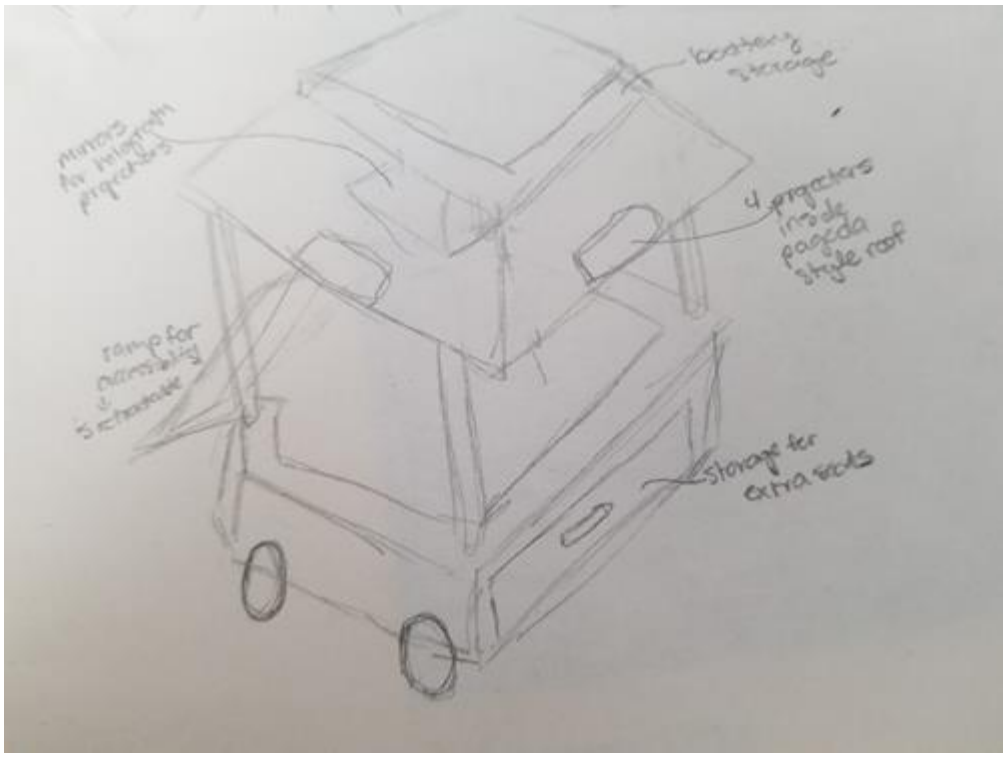
Movable components stay in place	DATUM	+	S	+	S
Design is intuitive		+	+	+	-
Enough space for 10-15 people		S	+	S	S
Adequate battery performance		S	S	+	+
Device Weight Tolerance		+	S	+	+
Wheels and brakes are present		S	S	S	S
Admin portion is available on online platform		S	S	S	S
# of pluses		**3**	**2**	**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.

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 criteria relating the concepts were created. After additional calculations, we were able to determine the optimal concept in the table below, which was concept 6.

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



Bill of Materials

- Materials
    - Metal
    - Wood
    - Laminated wood
- Tools
    - Saw
    - Screwdriver
    - Drill
    - Gloves
    - Tarp
    - Spray Paint
    - Car Jack
    - Wheel Chocks
    - Lug Wrench
- Roof
- Ramp
- Drawers
- Seats
    - Extra foldable seats
    - Cushions/Padding
- Main Cart

- Wheels
    - Axle
    - All terrain wheels
- Brake System
- Steering System
    - Handle
- Suspension System
    - Springs
    - Shock absorber
    - Stabilizer
- Display Devices
    - Screens
    - Projector
    - Projector mount
    - Mirrors
    - Mirror attachments
- Power Supplies
    - Wires
    - Electrical tape
    - Electrical outlets
    - Power surge protectors
    - Batteries
    - Charger for battery
        - Plugs or docking station
        - MAYBE Solar Panels
- Methods of Weather Proof
    - Flex Seal
    - Shades
- Connectors
    - Hinges for folding components
    - Screws, Nails, etc
- Chassis

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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 particular 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 members 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

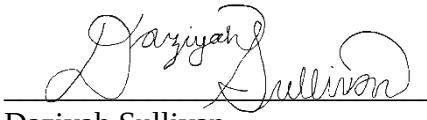
There are multiple issues that may arise throughout the course of the project, the following information provides steps for conflict resolution in a few of the potential issues.

- 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 make a decision 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

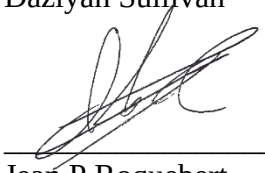
their inability to complete their tasks so that the rest of the team may accommodate, the team may vote on whether to inform the senior design instructor with three members voting yes warranting this response.

Statement of Understanding

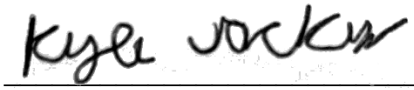
By signing this document, I acknowledge that the contents within will govern the actions of the group and agree with all terms set forth.



Daziyah Sullivan — 12/04/2019
Daziyah Sullivan — Date

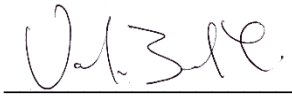


Jean P Roquebert — 12/04/2019
Jean P Roquebert — Date



Kyle Jackey — 12/04/2019
Kyle Jackey — Date

Michael Johnson — 12/04/2019
Michael Johnson — Date



Valeria Bernal — 12/04/2019
Valeria Bernal — Date

Yahdid James — 12/04/2019
Yahdid James — Date

Appendix C: Targets and Metrics

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 WiFi 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 are rollable, touch screen, and visible for every angle
6. Pearson pop-up classroom introducing digits^{n}: open one which can open another, 3D, consecutive reactive “discarry” 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 up 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 similar to 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 up to be more open to the environment
47. Use off road tires for increased mobility for different terrains
48. Delivery system similar to 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 and structural support for technology
51. Holographic 3D projection through a portable cannister
52. A large enough 3D projections 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 similar to 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 actually 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 similar to 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 night time 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.