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1 Problem Formulation

1.1 Introduction

This section of the document is to formulate an objective statement, give background of the problem, and to display a black-box model of our design's purpose.

1.2 Background

Our client representative is Pam Brittenburg. She is a teacher at Zane Middle School where they teach students numerous skills to provide a foundation for their future. Zane's academic program has a main focus on STEAM (Science, Technology, Engineering, Art and Math) to achieve their goal of excellence. The school is located in Eureka, California where rainy weather is common. To get out of the rain during lunch or break, students typically seek shelter in classrooms or the library. As expected, it can get pretty noisy in these spaces. While there are students who don't mind the noise, there are others who prefer peace and quiet to read a book or just to relax.

1.3 Objective

The objective of this project is to transform a plain space into an inviting and engaging learning environment suitable for students who prefer quiet and for those who don't. The design of this project will be based on advice and restrictions given by the client representative.

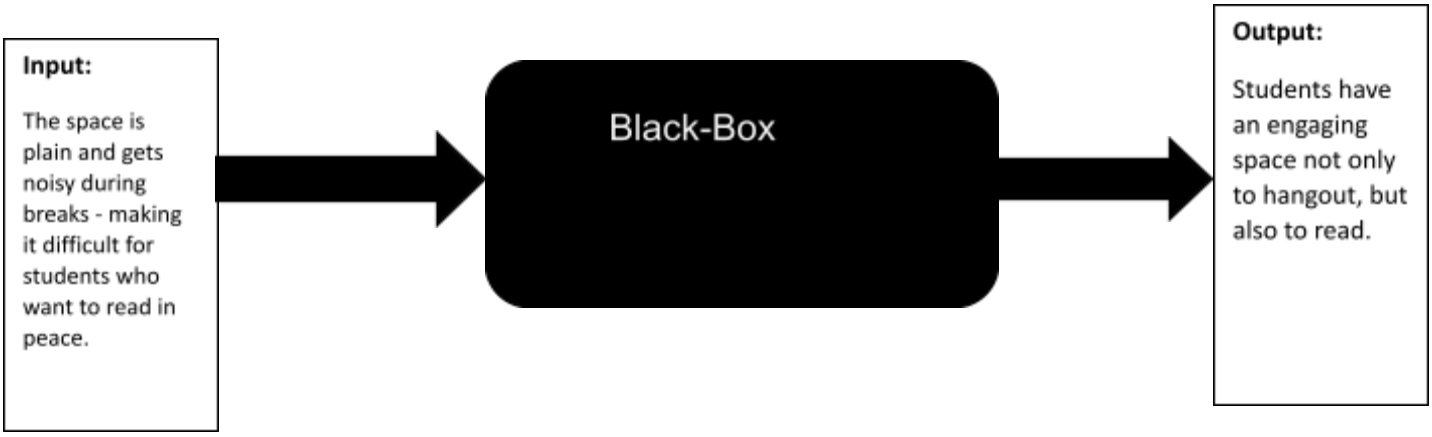


Figure 1.3-A: *This Black-Box Model gives us a simplified view of the design's purpose. This helps us define the solution and focus on the big picture without delving into details too much.*

2 Problem Analysis and Literature Review

2.1 Introduction to Section Two

Section two consists of the problem analysis and literature review. The purpose of section two is to provide detailed background of the problem and research that is relevant to the design. Learning the details of the problem, and investigating what has or has not worked for others, is useful towards achieving a successful design.

2.2 Problem Analysis

2.2.1 Specifications

The specifications that we have for this project help narrow down the design possibilities by considering the necessities and parameters of the project. The specifications for the creative internal space include the 7’ x 8’ space for the hangout area, and the 7’ x 8’ space for the reading area. Pre-existing furniture may be removed and walls can be painted if necessary. Any furniture that is implemented must be able to be removed in the likely event that the school decides to remodel the floors.

2.2.2 Considerations

The considerations for the project help define the circumstances under which the program will be implemented and used. One very important consideration is that the project will be used daily by students and therefore must be safe and durable. Additionally, the project must be able to be moved out of the classroom and back into the classroom without falling apart. Another consideration is that the project should allow for full visibility of the students, by the teacher, for safety reasons.

2.2.3 Criteria

2.2.4 Introduction to Criteria

The criteria of the project are the qualities that the project must have in order to fit into the client’s needs and specific use case. Table 2.2-A shows the criterion requested by Ms. Brittenburg and the necessary constraints the project must have in order to satisfy these requests.

Table 2.2-A: Criteria ranked from most important to least important.

Criteria	Constraints	Weight
Safety	The ability of the design to not harm its users, even in circumstances of extreme misuse.	10
Durability	The ability of the design to withstand constant use and misuse for at least 5 years.	10
Movability	The design must be able to be moved by two adults.	7
Aesthetics	The ability of the design to look non-sterile and fit a classroom setting.	7
Eco-friendly	Selection of materials should be made with the intention of being eco-friendly.	6
Affordability	Be within our $200 team budget and our individual $75 limit.	6
School Spirit	The ability of the design to evoke a sense of school spirit.	5
Inspirational	The ability of the design to remind students to be motivated and inspired.	4

2.2.5 Usage

Both the hangout and reading area are expected to be utilized by students everyday of the school week during break, which lasts about 30 minutes. On average, usage time per week would be about 3 ¾ hours. In order from least to greatest, the elements that will likely experience the most usage are the: bookshelf, chalkboard, reading pod, bucket seats, and foam flooring.

2.2.6 Production Volume

Our project was not designed with the intention of being reproducible. The space includes 6 bucket seats, a pre-existing table, one reading pod, one tree bookshelf, 80 ft^2 of foam flooring, and a 6 ft. by 6 ft. chalkboard.

2.3 Literature Review

2.3.1 Introduction to Literature Review

There are many aspects to this project. This literature review aims to consolidate information that is relevant to this project and that will inform all our decisions made as a group. The main components of this project that were researched are: Chairs, reading lighting, alternative bookshelves, quiet rooms, the psychological aspects of these type of hangout/reading areas, safety, allergies to materials, Floor materials, alternative table solutions, creative wall art and inspiration, Zane's Mission, Zane's history, and eco-friendly design themes.

2.3.2 Building Materials

2.3.2.1 Government-mandated Policies on Furniture Material Safety

To create environmentally friendly products, it would be ideal to reuse materials that would otherwise become waste. However, repurposed materials come with a risk that need to be assessed and handled to avoid causing health problems if they end up being used in an area with proximity to people, especially children. Generally, for materials to be considered safe, they must fall within federally-allowed levels of formaldehyde and lead. Additionally, upholstered items must meet specific furniture flammability requirements. California Chapter 862 (Upholstery Flammability) requires a manufacturer… "to indicate on the label whether or not the product contains added flame-retardant chemicals by including a specified statement on that label (Benson, 2016)."

2.3.2.2 Using Reclaimed Wood

Incorporating used wood comes with its benefits as well as its risks. First, it reduces the number of trees that need to be cut down for new building material. Increasing the number of trees in the ground is crucial to the health of our planet as trees take in carbon dioxide from the air. This is noteworthy because high concentrations of carbon dioxide negatively affect our global climate conditions. Second, aged wood possesses favorable properties compared to newer wood. "Reclaimed wood showed lower bending strength and hardness than recent wood. Drilling resistance showed reclaimed wood inner stability after years of weathering and environmental modifiers (Tansu, 2014)."

The risks associated with using reclaimed wood depend on its history. This reclaimed wood commonly originates from used furniture, flooring, cabinetry, old barns, factories, warehouse, or coal mines (Bauer, 2015). Thus, it is possible that the used wood could contain harmful substances, such as lead, certain paints and finishes, and metal debris, such as rusty nails. While these risks are dangerous, testing for them is relatively convenient. A metal detector and lead-testing kit from a local hardware store could be used to search for metal debris and toxins, respectively.

2.3.3 Seating

2.3.3.1 Seating in Schools

The seating in many of today's schools don't allow for students to sit in a natural position. The upright posture forced on students has required them to sit with the joints at their hips, knees and ankles at right angles. However, a 'normal' child can maintain this posture for no longer than 1–2 min (Mandal, 2009). Additionally, although students come in a variety of shapes and sizes, there is often only one uniform type of chair that may be less-than-suitable for many children. For instance, if a child is too tall for the chair or desk they are working at, they would be forced to slouch over their workspace, compromising good posture.

2.3.3.2 Possible Solutions to Helping Student Posture

While it may be impractical to expect children to spend less time sitting in the classroom, it is possible to make it so the way that children are sitting is supportive and healthy for their posture. When students,

who had previously used standard desks and chairs, started to use adjustable tables and chairs, there was a noticeable improvement in their muscle tension as well as their standing stature (Koskelo, 2007).

2.3.4 Bookshelves

Bookshelves are shelves on which books can be stored. Bookshelves must have enough strength to uphold heavy items. Books stand vertically, side by side with the spine of the book facing outwards in order to be identified by the title/author. The shelf needs to be level for the books to stand vertically and resist lateral movement to allow them to stand up straight when another book is removed from the shelf.

2.3.4.1 Content

More often than not, the subjects of diversity and identity are absent when stocking bookshelves in schools and other learning environments. For many years, grade school libraries have contained content that are generally exclusionary to those who fall outside "mainstream" cultural identities (Crisp, 2016). Although people have attempted to dismiss these disparities, these issues are overwhelmingly well established and evident (Hurtado, 2007). The content of books should account for the diversity of students at Zane Middle School in order to offer a better opportunity to broaden their cultural views.

2.3.4.2 Materials

Bookshelves are generally constructed from wood. The common required materials to construct a wood bookshelf are boards of wood, wood glue, wood screws, wood joiners, and flat washers (material size is ambiguous until the dimensions of the reading spot are specified). Bookshelves can also be manufactured from "milk"-type crates. These crates can be stacked on top of one another with the open side facing out to be used as a bookshelf. Unfortunately, when they are stacked up on top of each other, they can become unstable due to a lack of structural integrity since they are not joined together.

2.3.4.3 Slotted Bookshelf and Book Support

The "slotted bookshelf and book support" (shown in Figure 2.3-A) is designed to have a bookshelf with a slide-able book support connected to the shelf. This support acts much like a book end weight. It provides support to maintain the vertical position of the books and resist lateral disposition (Anders, 1964).

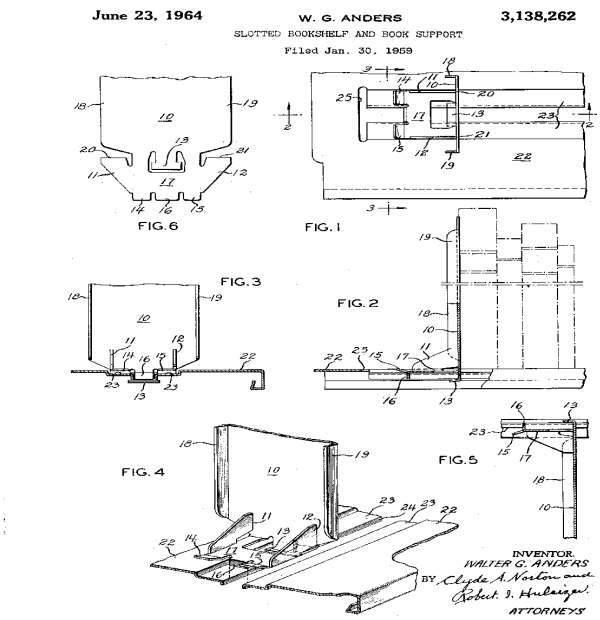


Figure 2.3-A: *This image is a depiction of a patent filed on January 30th, 1959 by Walter G. Anders. The patent shows a design for a book end/support that's built in to a bookshelf (Anders, 1959).*

2.3.4.4 Portability

In order to move a bookshelf from one location to another, one must remove all the books from the shelves. Then, box them up and transport them to the new location. This can be a very tedious and sometimes straining process. In order to make this process easier, wheels and shelf casing can be incorporated into the design of a bookshelf.

2.3.4.5 Portable Bookcase

This invention was created by Perry Grover in order to make transporting books much easier. The purpose of this invention is to provide a compact and portable bookcase that can be easily transported while also being loaded with books (Grover, 1920). When it is opened, it turns into a rack on which the books are mounted. The books must be dismounted for them to be opened.

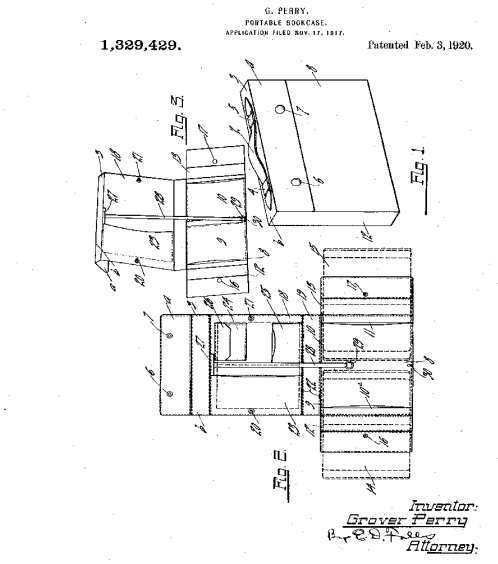


Figure 2.3-B: *This is a depiction of a patent filed on February 3rd, 1920 by Grover Perry. The patent shows a design for a portable bookshelf.*

2.3.5 Sound Absorption

Sound absorption is a main consideration that impacts the reading ability of students. One way that we can help combat that is using sound absorption. Sound absorption is the measure of sound loss after the sound waves bounce off a surface. A lot of sound absorption creates a space without echo, also called an "anechoic space (Vorlander, 2008)." For example, when a sound studio uses thick foam coverings on walls and thick carpet for floors, the intent is to absorb the sound and, in doing so, create an anechoic environment. This section will explore what materials are best for sound absorption and other acoustic aspects that could influence our design.

2.3.5.1 Materials of Interest

In order to discuss sound absorption we must define some terms that are instrumental in understanding it. First, sound attenuation is quantified using a number between 0 and 1. This number is referred to as the Sound Absorption Co-efficient (SAC) (Amares, 2017). The higher the SAC for a material, the better the material is at absorbing and not reflecting sound. The SAC for a material changes for different frequencies of sound. Since we are looking to dampen sound from human voices, it is only appropriate to consider only the SAC values for materials under a frequency of 300 Hz. 300 Hz. is above the maximum frequency of a human voice (Titze, 1994).

Table 2.3-C: Sound Absorption Coefficients of feasible project material at different frequencies.

Material	**Sound Absorption Coefficient at 125 Hz. And 250 Hz.**	
	125 Hz.	250 Hz.
Linoleum on concrete	0.02	0.03
Cotton Carpet on concrete	0.07	0.31
Cork Tile on Concrete	0.02	0.03
Rubber Carpet on concrete	0.04	0.04
Gypsum Board	0.30	0.69
Acoustical Plaster	0.17	0.36
Rockwool (50 mm)	0.22	0.59

2.3.5.2 Implementing Sound Absorption Principles

One critical aspect of sound dampening is enclosing the area that is to be quiet. In an interview with an expert on the matter, Chief of Enterprise Security at Edwards Air Force Base, Matthew Detloff gave us valuable information. Edwards Air Force Base is home to the largest anechoic facility in the world. When Mr. Detloff was asked what the most important thing about sound proofing is, his response was as follows, “Soundproofing is first and foremost about blocking the sound coming in via structure. Something like walls and a ceiling protect from incoming soundwaves.” We then took him through our project overview. His suggestion to absorb sound most effectively given our parameters and considerations is as follows: “Well, you can’t very well make a completely sealed room inside of a class room… The level of sound attenuation you all need to achieve, however, must use some level of enclosure (Bardin, 2019).”

2.3.5.3 Quiet Pods

Pod chairs are chairs that provide a bit more privacy to whoever sits in them. This addition of privacy is done by covering more space around the occupant than traditional style chairs. An example of this style of chairs hanging or attaching a helmet type fixture above where a potential occupants head would be. Others are egg-shaped recliner chairs that have walls that encompass the occupant. More minimalistic designs like “Privée” consist of chairs with enclosed canopies. Privacy Desk Pods are desks that encompass the occupant without it being necessarily attached to the chair itself.

2.3.5.4 Affordability

The previously mentioned desks/chairs cost upwards of $500 per unit. However, making them will reduce the cost significantly. A cost analysis table containing the cost of constructing The Canopy pod concept can be found below

Table 2.3-A: Cost of materials to make canopy pod chair design (very rough estimation).

Material	Cost
Cushions	$0-$80
Chair Legs	$0-$90
Sound Dampening Fabric	$70-120
Plywood	$0-$45

2.3.6 Psychological Aspects

2.3.6.1 Conditions as They Relate to Reading

There are multiple conditions which interfere with reading in children. Dyslexia is characterized by difficulties with accurate word recognition, poor spelling and decoding abilities (Wilkinson, 2012). A study showed in the United States, dyslexia effects 5% to 17% of school-age children with 40% reading below grade level (Shaywitz, 2003). People often categorize this condition as a person seeing letters backwards or rearranged. However, most children dealing with dyslexia often have difficulty with linguistics outside of the trope of seeing letters out of place. Another painful grade school problem is reading aloud in the classroom. Reading aloud is a task that is common amongst grade schools to keep children focused. “The task activates the amygdala, the part of the brain which elicits an immediate sense of dread and fear” (Wilkinson, 2012). Many children also struggle with reading aloud to classmates due to the embarrassment of fumbling on words or reading too slowly. Hyperactivity is also a common condition which effects the reading abilities of children. A study on hyperactivity in adolescents from the University of Otago Medical School showed a correlation between how the condition relates to school performance. The results concluded that, “hyperactivity was associated with continuing school difficulties, problems with attention, and poor reading in adolescence” (McGee, 2002).

2.3.6.2 Best Reading Environments

Noise and crowding are both elements that affect the instructional process (Graetz, 2003). A study by Nguyen and Grahn examined the effect of background music on different types of memory. Different background music was used to create different memory contexts (Nguyen, 2017). The study resulted in the participants recalling more words when they listened to low arousal music than high arousal music. For recognition memory, participants recognized more words when they listened to low arousal music than high arousal music as well. Introverts tend to be impaired on tasks accompanied by background music when compared to extraverts (Dobbs, 2011). The current scientific studies seem to indicate that music does not always aid cognitive performance, listening to heavy lyrical music, for instance, can

impair performance of reading comprehension (Perham, 2014). However, variance in studies shows the correlation between music and reading comprehension to differ on a per individual basis.

2.3.6.3 Claustrophobia

Claustrophobia is an anxiety disorder that has to do with a discomfort with small spaces. People affected by claustrophobia typically notice symptoms during childhood. In an informational article about claustrophobia, Paddock explains that the symptoms of claustrophobia are triggered by being in or thinking about being in a confined space (Paddock, 2017). Symptoms of claustrophobia include hyperventilating, sweating, a choking sensation, nausea, trembling, etc. (Paddock, 2017). It is important to note the places or situations that can cause symptoms of claustrophobia. These include but are not limited to, small rooms, rooms with no windows, crowded places, and public bathrooms.

2.3.7 Floors

2.3.7.1 Rubber Flooring

Rubber flooring is a resilient flooring that provides a durable and easy to clean surface that can last a long time. Rubber flooring is suitable for hard-wearing environments such as gyms, basements, rec rooms, playrooms and utility rooms (Lewitin, 2019).

2.3.7.2 Pros of Rubber Flooring

A major benefit of rubber flooring is that it is resilient under a variety of conditions. It is water and mold resistant, which is appropriate for Eureka's wet climate. Rubber flooring is also very easy to maintain cleanliness. According to Lewitin, it is very easy to clean rubber flooring because it generally doesn't require anything more than a damp mop to clean it.

Rubber flooring is also very soft beneath the feet. The thicker the rubber, the softer it will be. The softness is due to the elasticity of the material which makes rubber flooring quiet to walk on.

2.3.7.3 Cons of Rubber Flooring

Some disadvantages of rubber flooring include cost, slippage, staining, odor, and fire hazard (synthetic rubber). The price of rubber flooring can vary from $2-$15 per square foot. Due to that untextured nature of rubber, it can become slippery when wet. Although rubber flooring is resistant to most staining agents, grease, oil, strong detergents and abrasive cleaning liquids can be harmful to rubber floors. New rubber floors often come with an undesired odor that will eventually go away. When exposed to substantial heat, the rubber may catch fire (Lewitin, 2019).

2.3.7.4 Exercise Floor Mats

Exercise mats are a soft flooring material commonly used in gyms, martial art gyms, and playrooms. They are made soft rubber or foam materials in order to prevent harm when falling on them. They vary in

prices depending on size and thickness. They are sold by the square foot and generally cost $10-$30 per square foot and come in a variety of different colors.

2.3.7.5 EVA Foam

Ethylene-vinyl acetate is a closed-cell, dense resilient foam that is commonly used in the production of mouse pads, shoes, automotive parts, athletic equipment padding and mats, as well as children's two-dimensional toys (Kessler, 1999).

2.3.7.6 Spillage control and Safety

Punctured rubber or plastic floor mats are useful for providing a safe and non-slip surface (Kessler, 1999). The holes in the mats allow for spillage of drinks, water or any other ambiguous liquids to pass through the mat and rest at the bottom instead of the top layer, where it can become slippery. Thin rubber floor mats can be transportable by simply rolling them up and relocating them. Thick rubber mats (1/2" or more) can be quite heavy. Therefore, thin rubber mats (<1/2") are preferred in order to make transportation easier (Kessler, 1999). These mats are connected via interlocking ends that can be modified by the user.

2.3.7.7 Non-Slip, Wear-resistant Tread

The purpose of this invention is to provide a nonslip, easy to install, light weight, nonflammable, high electrical resistance, highly moisture resistant and resistant to organic chemicals tread that has substantially harder nonslip abrasion-resistant discrete particles embedded in and firmly bonded to the body material (Sayre, 1941).

2.3.8 Table

2.3.8.1 Interaction

An article from Teach for America explains there are two main types of tables among schools. The two classifications are groups and rows. Not until the 20th century was the design concept of flexibility introduced into the classroom. This inventive school environment included moveable desks and tables, usable wall surfaces, and smaller spaces for learning activity apart from the teacher (Woods, 2009). Teach for America identifies pros and cons of common table types. The issue with grouped tables is the possibility of side conversations or even conflict between students. Rows of singular tables are beneficial due to the decrease in distractions. However, there is less interaction between students and is also less space effective (TFA, 2016). A study by Caroline A. Guardino and Elizabeth Fullerton demonstrated the correlation between the arrangement of classroom furniture and students' academic engagement as well as their behavioral problems. The results are as follows: "after we modified the classroom, academic engagement increased immediately and stayed at or near 45 %" (Guardino, 2010).

2.3.8.2 Materials, Durability, and Affordability

Learning spaces need to be flexible, not fixed, and open to minor changes (Roskos, 2011). A New York Times article explains the difference in the types, sizes, and cost of different tables. “Square and rectangular tables are the most common. But a round or oval table can give you a little more space to move around since it cuts off the corners but still has a good surface area,” said Ayn-Monique Klahre. The article goes on to state that a table with thinner legs makes it easier to add more people to the table (Klahre, 2018). Plastic tables are an inexpensive option because they are easily accessible and can be widely manufactured. Plastic materials tend to resist staining and require little upkeep. However, they’re often cheaply made and do not last as long (Klahre, 2018). Wood is another common material used for tables. The benefit of using wood material is it’s durable and easy to repair. There are different types of wood used to construct tables, all differing in cost. However, Klahre avers, “wood expands and contracts with heat and humidity and can show scratches and wear but is fairly easy to repair.”

2.3.9 Walls

2.3.9.1 Chalkboard Walls/Paint

Chalkboards are extremely common in grade schools and used frequently. An alternative to a chalkboard is chalkboard paint. This allows users to turn any wall or surface into a chalkboard. The most common chalkboard paint used is manufactured by Rust-Oleum®. The safety label found on this product states it is unleaded - Safe for use on children’s toys, and furniture and “Child-safe. Non-toxic when dry”(Rust-Oleum® Corporation, 2003). An article by Angela Colley on how to use chalkboard paint recommends to make sure the surface in which the paint is being applied to be smooth and to also not paint over any cracks or holes for best results. Colley states “Don’t use chalk markers, use real chalk." The paint also takes multiple layers and approximately three days to completely dry (Colley, 2016).

2.3.9.2 Inspirational and Engaging

Walls, which are commonly overlooked in the classroom, can contribute more to the learning environment. In the classroom environment, word walls, student work displays, and message boards all improve overall environmental quality (Roskos, 2011). Kids need some educational displays to engage them in the classroom. Student interaction is facilitated by all matter of effects. These effects include: the distribution of color that is chromatically “hospitable,” tactile qualities that allow for touch, and light that is enough and differentiated” (Roskos, 2011). However, too much visual stimulation can negatively impact learning. A study published May 2014 in Psychological Science from the Carnegie Mellon University looked at whether classroom displays affected children’s abilities to stay focused. The lead author, Anna Fisher, said, "Young children spend a lot of time in the same classroom, and we have shown that a classroom's visual environment can affect how much children learn.” The results of the study showed that children learned more when the room was not heavily decorated(Carnegie Mellon University, 2019). Fisher, however, suspects that what’s on the walls is less significant in the upper grades because, “concentration improves as children age.”

2.3.9.3 Colorful

Some students (such as those with Attention Deficit/Hyperactivity Disorder) may be more sensitive to color in the learning environment due to heightened sensory responses and strong visual processing abilities (Freed, 1998). Research by Torice and Logrippo has shown that active children prefer cool colors and passive children are more comfortable surrounded by warm colors (Gaines, 2011). Different colors have certain correlations to mood and productivity. Excessive use of color could cause a stressful learning environment. In a study by Terwogt and Hoeksma, people from different age groups were asked to link colors to emotions and more preferred colors were tied to highly preferred emotions. Results showed brighter colors such as blue, red, and yellow were preferred by kids ages 7-11. The less preferred colors were green, white, and black which were correlated with sadness, aversion, and fear (Terwogt, 1995).

2.3.10 Design Influences

2.3.10.1 School Colors

Zane's school colors are red and gold. Zane's school mascot is the Falcon. Trevor Hammons, Zane Middle School counselor, believes that the implementation of these themes is very important to the success of the project. A school mascot and color scheme can give students something over which they can unite. Even if students have nothing in common, they have the Falcon in common. This gives a student a sense of belonging and it gives the community something to rally around as well (Krueger, 2019).

2.3.10.2 Eco-Friendly

Humboldt State University has one overarching theme that dictates campus classes, activities, workshops, economy, and even clubs. That theme is sustainability. Sustainability can be taught at an early age. Things like, teaching nature, healthy and sustainable communities, the dangers of excessive consumption and knowing well the places we work and learn are things that can be taught to ingrain every student with an innate sense of sustainability (Alessandro, 2016).

2.3.11 Zane Middle School's Mission

2.3.11.1 Self-Worth

One very important consideration to make is the client and what the client represents. In Zane Middle School's mission statement, the ability of a student to value themselves is heavily emphasized. This was reaffirmed through correspondence with our client representative, Pam Brittenburg. Pam mentioned that her students value good quotes and inspiring sayings that they can recall when they are feeling overwhelmed.

2.3.11.2 Personal Responsibility

Zane's mission statement also explicitly states that there is an emphasis on personal responsibility. Things like cleaning up an area after you're done with it and things like completing assignments on time.

This can be accomplished by showing students the way that they can clean up the space. Also, there should be consequences for not showing personal responsibility (Friedman, 2017). These consequences are at the complete discretion of the adult.

2.3.11.3 Diversity

Diversity is something that Zane takes very seriously. There are many ways to teach young people about diversity and acceptance. One that works very well is exposure. Just exposing a child to role models from different cultures and of different identities can go a long way to increase diversity and acceptance. Another way to implement this very important principle is to teach children to accept and celebrate differences (Pulido-Tobiassen, 1999). This can be accomplished by talking about differences, model good behavior and attitudes toward diversity, not letting prejudicial or racially charged remarks go by without intervening and creating opportunities for kids to interact with someone who is different from them (selective group project assignments or interview assignments) (Pulido-Tobiassen, 1999).

3 Alternative Solutions

3.1 Room Concepts

3.1.1 First Concept

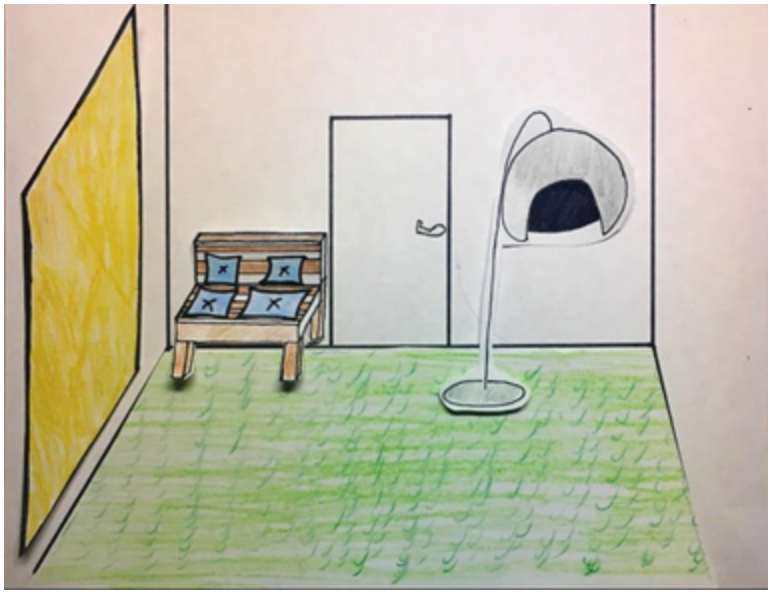


Figure 3.1-A: *Drawing of first alternative solution "The Rustic Hair Salon."*

Our first design alternative consists of a pallet sofa, bulletin board, astroturf, and a hairdryer pod. Although this choice was not our first runner up, there are some good aspects about it. The pallet sofa

would be durable and flexible for design. “Items made from pallet wood are likely to be durable and demonstrate good weather resistance due to these treatments” (Wikipedia). In 1999, a design firm in New York won an award for refugee homes they created out of pallets. The pallet sofa is about 1.2 m wide and 0.8 m long. The legs are made of “square leg cut-offs.” It would weigh around 50-60 lbs. However, it could potentially be dangerous to children due to its weight and also has potential to be loud and squeaky. The hairdryer pod is about 2 m tall. The hanging aspect makes it dangerous and also is very space inefficient. It is not one cohesive unit therefore it wouldn’t stay together and would end up not in use. The bulletin board is made out of cork and is meant for hanging messages or pictures. It varies in sizes from small to very large. They are fairly durable however, are not different from other basic classroom decor and limited on abilities (i.e decorative, and interactive). Things pinned to bulletin board can get lost or ruined. The pins used to hang things up are also easily removable and could be dangerous. The flooring would be made of astroturf it is synthetic grass that is used as an eco-friendly alternative to grass. Often made from recycled rubber from car tires. Astro turf can be compared to a rubber carpet, it collects bits and pieces of dirt and liquids from humans (sweat, blood, or saliva). Therefore, it is required that you spray it with water to effectively clean it. Which would be impractical to do inside of a classroom. It is also not very soft or comfortable to sit on, as it is a rather rough material that can cause abrasions of the skin when fallen on.

3.1.2 Second Concept

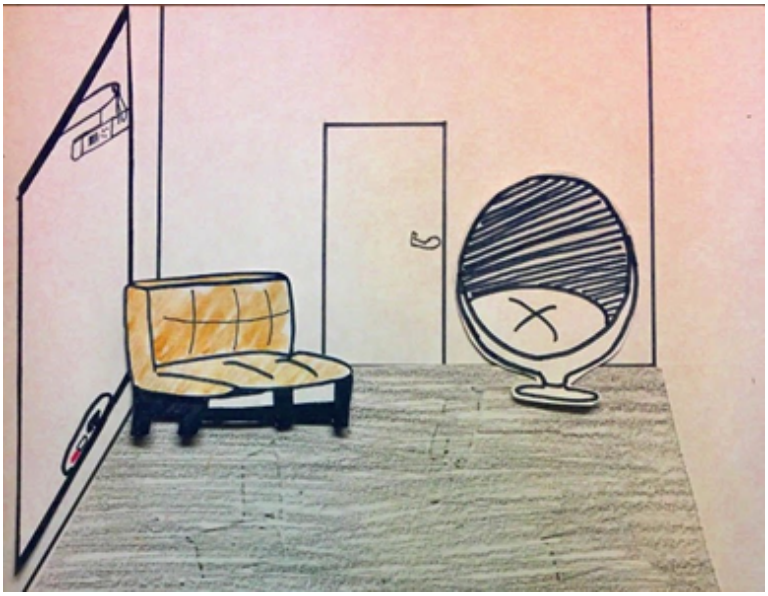


Figure 3.2-B: *Drawing of second alternative solution, “A Futon of Fun.”*

Our 2nd room concept incorporates a Futon, SMART board, Rubber flooring, and the Egg Chair Pod design. The aspects of this concept that could potentially work are; Futons can be folded up and stored easily. They’re about as heavy as a pallet sofa, so around 50 lbs. A twin futon is about 1 m x 2 m. Futon legs vary; for example, rust resistant chrome metal legs with anti-slip on the bottom. The SMART board adds a futuristic and innovative vibe. Rubber flooring is rated high for safety features and reduces the

risk of children getting hurt. Plus it provides a comfortable alternative to sit on. The Egg Chair would provide a place for the students to escape to in order to read in solitude and focus on their studies. On the other hand, the handful of negative aspects are; kids might fall asleep on the futon due to it being too comfortable and relaxing. The SMART board is 135 cm tall and the writing is large, messy, and blocky. They are also expensive to buy, and must be hooked up properly in a specific area along with a projector and a computer hooked up. Rubber flooring has an expensive initial cost. It can also become loose and split apart, presenting tripping hazards and environments suitable for harmful bacteria and mold to grow. It is also a flammable substance. The dimensions of the Egg Chair would be about 1m tall and .5 m wide. Which could potentially cause claustrophobia. It also does not allow for proper supervision and only allows for single person use.

3.1.3 Third Concept

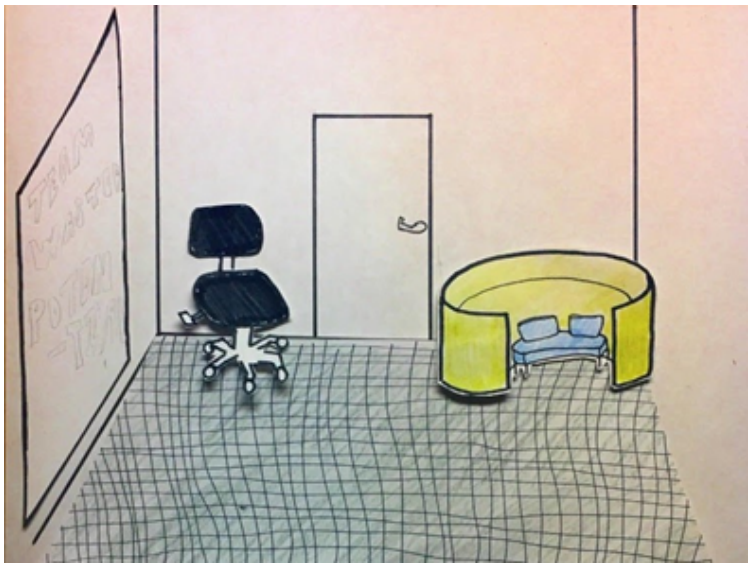


Figure 3.1-C: *Drawing of third alternative solution, "Ye Olde Office."*

For our 3rd room we would use rolling chairs, carpet flooring, a whiteboard, and a cubicle. The things that would work about this are that the carpet is nice and soft, the cubicle provides great sound attenuation due to it having 3 walls, also, a whiteboard is much easier to maintain, and it eliminates chalk, which can be messy. However, more things are wrong with this design than things are right. The fact that a white board sort of gives off a School vibe by itself was something disqualifying for us. Whiteboard markers are bound to be lost or left open to dry out. The rolling chair also presents many problems. Their ability to swivel could lead to misuse. Also, the possibility of mud getting in the casters my lead to wear and tear. Cubicles are great in principle. However, the fact that they are enclosed is the main problem. The kids need to be supervised, obviously, the more walls, the more obstructed that supervision is. Carpet is a material that can get dirty very easily. Given that we are making this where the weather is harsh and wet, a carpet would immediately get dirty and would be costly and expensive to maintain cleanliness.

3.1.4 Fourth Concept

Figure 3.1-D: *Drawing of fourth alternative solution, "A Night Under the Stars."*

The 4th room would consist of Tree trunk chairs, a bulletin board for decoration, mattress topper flooring, and an egg chair for quiet reading. The tree trunk chairs are not the easiest to move unless modifications were made to the bottom. They could be extremely heavy. May also be uncomfortable to sit on and no long-term back support and not be appropriate for all sizes. The bottom would be flat so it may be unstable on squishy material. However, they wouldn't take up all that much space and could be used for storage as well. The bulletin board is made out of cork and is meant for hanging messages or pictures. It varies in sizes from small to very large. They are fairly durable however, are not different from other basic classroom decor and limited on abilities (i.e decorative, and interactive). Things pinned to bulletin board can get lost or ruined. The pins used to hang things up are also easily removable and could be dangerous. Mattress toppers are a soft bedding material that could provide a comfortable place for students to sit on the floor. They will need to be paired with a waterproof casing in order to prevent them from soaking up liquids. Mattress toppers are made for sleeping on and may become deformed from constant foot traffic. Lastly, the egg chair is about 1m tall and .5 m wide. It has potential for being claustrophobic. It also does not allow for proper supervision and only allows for single person use.

3.1.5 Fifth Concept

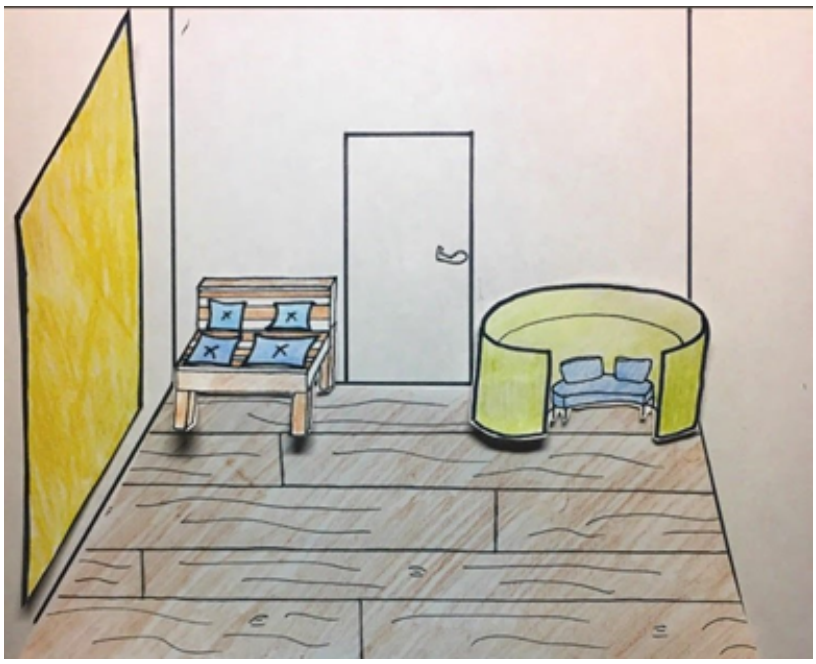


Figure 3.1-E: *Drawing of fifth alternative solution, "Edgar Allen Poe."*

Our 5th room would include a Pallet Sofa, Bulletin Board, Faux Hardwood flooring, and a Cubicle. The aspects of this concept that could potentially work are; a pallet Sofa is very easy to construct and extremely cheap as well. A bulletin board would allow for intricate aesthetics to be displayed and easy to change decorations. Faux hardwood floors ae stain, scratcha and water resistant. The cubicle provides great sound attenuation due to it having 3 walls. On the other hand, there are a handful of negative aspects that would compromise the project. For one, The pallet sofa may be somewhat dangerous and would require copious amounts of finishing and sealing in order to make it water resistant. Two, bulletin boards are no different from other basic classroom decor and limited on abilities (i.e decorative, and interactive). Things pinned to bulletin board can get lost or ruined. The pins used to hang things up are also easily removable and could be dangerous. Three, faux hardwood floors are expensive and uncomfortable to sit on. Plus, it must be installed into the ground which will not comply with the constraints of the project. Lastly, the cubicles would obstruct the teacher's ability to supervise the students effectively.

3.1.6 Sixth Concept

Figure 3.1-F: *Drawing of sixth alternative solution, "Didn't I Just Get My Hair Done?"*

This room would include a Pallet Sofa, a Whiteboard, Polypropylene Rugs for flooring, and a Hanging Pod concept for the sound dampening aspect. There are some good things about this room. A pallet Sofa is very easy to construct and extremely cheap as well. The hairdryer concept looks futuristic and is easy to manufacture. Polypropylene rugs are water resistant and easy to keep clean. And a whiteboard is simpler and easier to maintain than a chalkboard. However, there are some negatives to these solutions as well. The Pallet Sofa is somewhat dangerous and would require a ton of finishing and sealing in order to make it water resistant. The rugs are very easy to clean, but they aren't very durable. Many rugs also contain toxic chemicals that aren't environmentally healthy. The hanging pod concept seems simple but may be dangerous. Since the concept involves a free-swinging helmet, the kids might want to mess with each other by swinging it. And, as stated before, the whiteboard is too sterile and school-like to fit the motive of this design.

4 Decision Process

4.1 Introduction

This section will outline our decision process and decision specifications. We will evaluate all of the Alternative solutions from the last section and compare their different strengths and weaknesses using the Delphi method. This process will determine the best solutions using the Delphi Method according to our criteria outlined in Section 2.

4.2 Criteria

Figure 4.2-A: Criteria that will be considered when making design decision.

Criteria	Constraints	Weight
Safety	The ability of the design to not harm its users, even in circumstances of extreme misuse.	10
Durability	The ability of the design to withstand constant use and misuse for at least 5 years.	10
Movability	The design must be able to be moved by two adults.	7
Aesthetics	The ability of the design to look non-sterile and fit a classroom setting.	7
Eco-friendly	Selection of materials should be made with the intention of being eco-friendly.	6
Affordability	Be within our $200 team budget and our individual $75 limit.	6
School Spirit	The ability of the design to evoke a sense of school spirit.	5
Inspirational	The ability of the design to remind students to be motivated and inspired.	4

4.3 Solutions

This section will list the solutions that are to be considered. The following solutions are from Section 3: Alternative Solutions, detailed descriptions of each are located there.

- The Rustic Hair Salon
- A Futon of Fun
- Ye Olde Office
- A Night Under the Stars
- Edgar Allen Poe
- Didn't I Just Get My Hair Done?
- Internal Creative Learning Space

4.4 The Decision Process

The technique used to decide our design is a Delphi Matrix method. Each criterion listed above is given a specific weight from 1-10, based on importance of the criteria. If a criterion has a weight of 1, it can almost be ignored if put up against other, more important criteria. If a criterion has a weight of 10, the importance of it cannot be neglected and the importance of it will overpower other aspects with lower weight. For example, if something fits into eco-friendly very well, but it does not fit durability very well, that design is seen as a lesser option than one that fits higher-weight criteria better. These weights were reached via discussion amongst the group. After that, the group must reach a consensus to rate all alternative designs based on how well they fit in to these criteria, this scale is measured from 0-50. 50 being a design that meets a specific criterion the best.

Criteria	Weight (0-10 high)	Alternative Solutions (0-50 high)						
		Rustic Hair Salon	Futon of Fun	Ye Olde Office	A Night Under the Stars	Edgar Allen Poe	Didn't I Just Get My Hair Done	Foam Bounce
Durability	10	30 / **300**	20 / **200**	38 / **380**	37 / **370**	35 / **350**	37 / **370**	44 / **440**
Eco-friendly	6	45 / **270**	10 / **60**	28 / **168**	42 / **252**	37 / **222**	28 / **168**	40 / **240**
Affordability	6	39 / **234**	5 / **30**	29 / **174**	36 / **216**	30 / **180**	31 / **186**	41 / **246**
Safety	10	34 / **340**	34 / **340**	39 / **390**	36 / **360**	40 / **400**	34 / **340**	46 / **460**
Movability	7	45 / **315**	34 / **238**	26 / **182**	38 / **266**	39 / **273**	40 / **280**	42 / **294**
Inspirational	4	32 / **128**	12 / **48**	37 / **148**	38 / **152**	38 / **152**	25 / **100**	37 / **148**
School Spirit	5	25 / **125**	0 / **0**	33 / **165**	33 / **165**	33 / **165**	25 / **125**	46 / **230**
Aesthetics	7	30 / **210**	39 / **273**	22 / **154**	32 / **224**	37 / **259**	36 / **252**	45 / **315**
	Total	**1922**	**1189**	**1761**	**2005**	**2001**	**1821**	**2373**

Figure 4.4-A: *This is the Delphi Matrix for our alternative solutions.*

4.5 Final Decision

We chose the design “Internal Creative Space” as our final decision. The final decision was made by using a combination of the Delphi Matrix, the client’s input, and the team’s discretion. The Internal Creative Space concept had the highest score in the Delphi matrix chart which contributed a great amount to it becoming the final decision. It is important for the floor to be safe, durable and soft as well as moveable. Therefore, the foam flooring would be the best fit. The reading pod was also the best decision because it has the highest potential of functioning properly, least amount of injury (none expected) and easiest to transport. The combination of the Foam floor, Reading Pod, chalkboard, and bucket seats make for the most ideal hangout and reading spot for students to escape from Eureka's weather and have a cool area to read or hang out inside a classroom without feeling like they are in a classroom environment.

5 Specifications

5.1 Introduction

This section of the document will describe all aspects of our solution. This includes: an overview of the solution, the costs of implementing this solution, the operational and maintenance costs of this solution, the prototyping that went into finding this solution, the instructions for how to implement this solution in the best manner, and the results of how the model works once implemented.

5.2 Description of Solution

Our solution can essentially be broken down into 2 areas: the reading area and the hangout area.

Both areas have the same flooring tiles. These tiles are made from high-density, closed cell, non-toxic EVA foam. The tiles are 2 feet square and 7/8 inch thick. They are also red in color. Each area will get 40 square feet of tile.

5.2.1 The Hangout Area

In addition to the foam flooring, the hangout area has: bucket seats, a chalkboard, and a table.

The bucket seats are 4.5-gallon buckets that were spray painted gray. Added to the buckets was a piece of upholstered plywood with added polyurethane padding for comfort. 6 bucket seats were made in total.

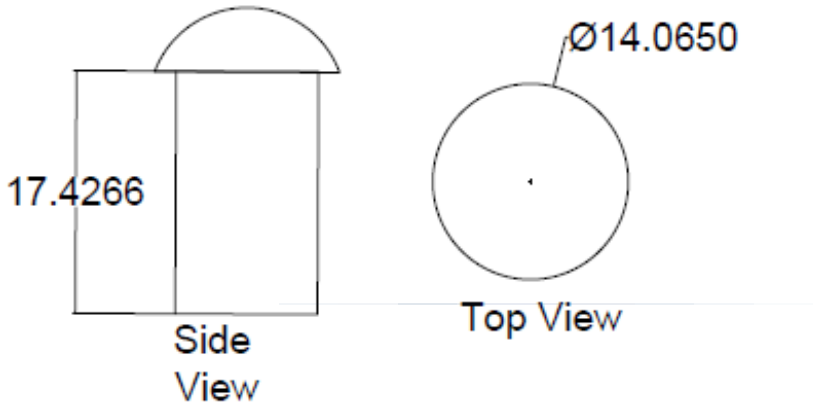


Figure 5.2-A: *Dimensions of Bucket seats.*

The chalkboard has dimensions of 6 feet squared. It is produced using Rust-O-leum black chalkboard paint.

The table that we are using is a pre-existing table in the classroom.

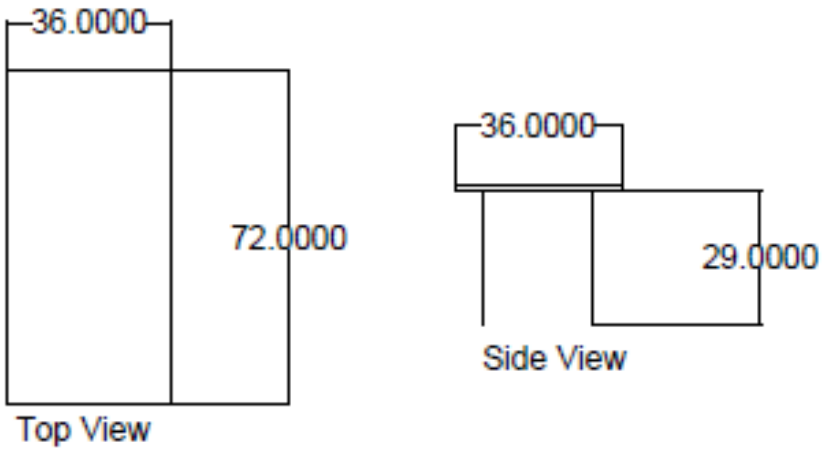


Figure 5.2-B: *Dimensions of table (inches) .*

5.2.2 The Reading Area

In addition to the foam flooring, the reading area has a reading pod and a tree bookshelf.

The reading pod is made from recycled CDX plywood, 1-inch Aluminum square tubing, plastic joints, upholstery fabric and polyurethane padding. The skeleton of the pod is constructed using the 1-inch aluminum tubing. The dimensions of the skeleton are 4.25 feet tall, 3.5 feet wide, and 3 feet deep. This skeleton is joined in its 8 corners by plastic joints. The panels of the pod are made from 5/8-inch thick CDX plywood. This plywood is upholstered using vinyl fabric and polyurethane padding for comfort. The panels are then joined to the skeleton using a combination of bolts and screws for ease of disassembly.

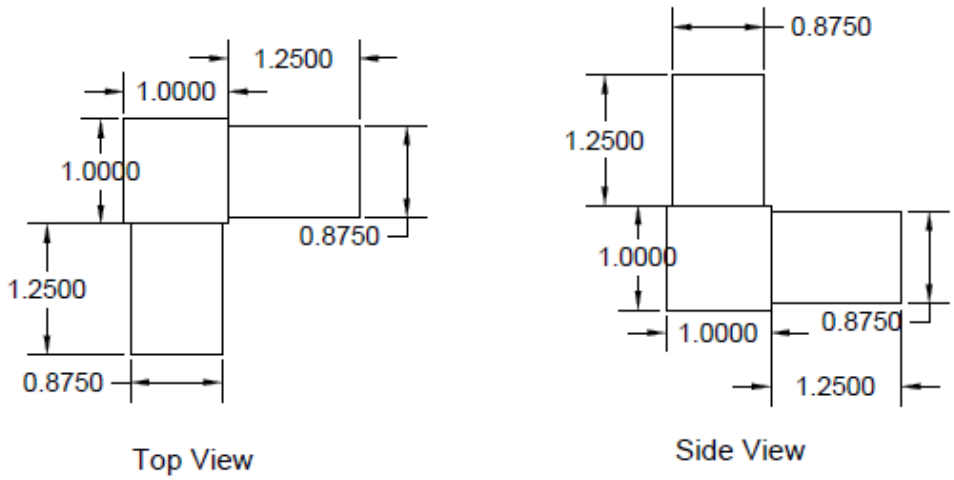
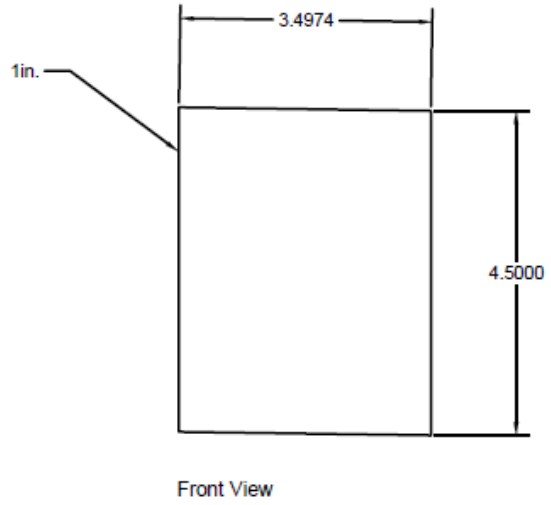


Figure 5.2-C: Dimensions of reading pod.



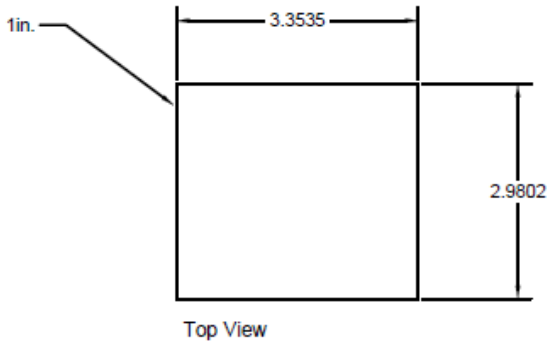


Figure 5.2-D: *Dimensions of front of reading pod(ft)*

Figure 5.2-E: *Dimensions of top of reading pod (ft)*

The tree bookshelf is made from 5/8-inch thick CDX plywood. The lengths are all 8 inches deep and are cut at various lengths and fit together at various angles in order to look like a tree. The shelves are supported by brackets that are drilled into the wall and into the shelving units.

5.3 Costs

5.3.1 Design Cost in Hours

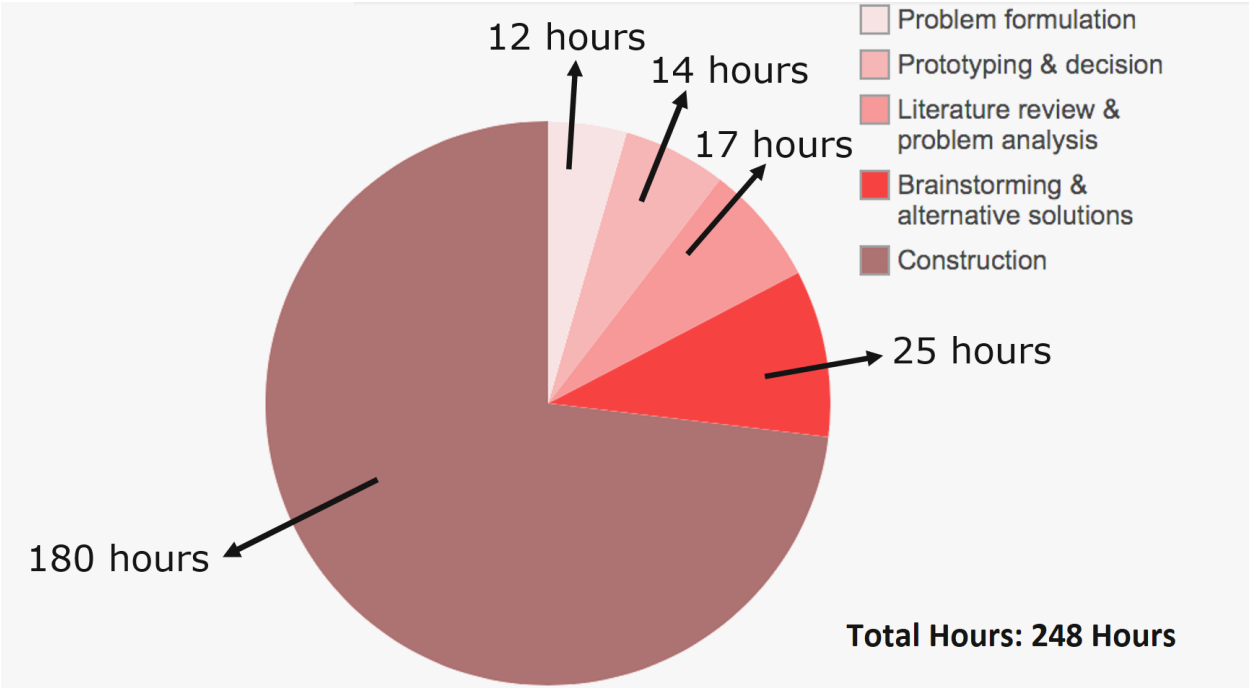


Figure 5.3-A: *Pie chart of work hours*

5.3.2 Implementation Cost in Dollars

Table 5.3-B: *Cost chart*

Item	Quantity	Cost	Our Cost
Closed-Cell EVA Foam	80 sq. ft.	$150	-
5/8-inch-thick CDX plywood (4ft.x8ft.)	5 sheets	$135	$80
Exterior Oil-Based Semi-Transparent Stain	1 gal.	$40	-
Aluminum Square Tubing (1in.x1in.)	90 ft.	$355	$85
Pod Upholstery Fabric (4.5 feet wide)	75 ft.	$115	$115
Bucket Seat Outdoor Fabric (3ft. wide)	18 ft.	$54	$35
Spray Paint	6 cans	$21	$21
Chalkboard Paint	1 can	$16	$16
Plastic Joints	16	$60	$60
Pop Rivet gun	1 gun	$20	-
Mattress padding (6.7ft.x3.2ft.)	3 sheets	$90	-
Jigsaw	3-day rental	$50	-
Upholstery Glue	2 cans	$20	$20
Total		**$1126**	**$432**

5.3.3 Operation Cost in Dollars

Taking care of the space is straightforward. Maintenance is walking around with paper towels and a disinfectant and cleaning any spills or messes that occur in the areas. We estimate that the maintenance will cost $20 a year and about an hour of time per month.

5.4 Prototyping

Only one aspect of the solution had a prototype done for it. There are many cheap versions of the flooring that we wanted to use. A basic and cheap section of flooring stood up to may conditions. The tiles were placed in high traffic areas to observe how they handled stress. They handled the usage well. This was surprising to us because even in a household with dogs, the flooring held up for about a week.

5.5 Instructions for Implementation and Use

To implement the flooring, tape the underside of the tiles where the tiles connect. Then lay the tile down. Any maintenance on the flooring will come once the tape begins to lose grip and the tiles begin to separate.

To implement the chalkboard, provide chalk for the students to use on the painted chalkboard. The maintenance for the chalkboard is to make sure it is erased at the end of every day.

To implement the reading pod, simply attach the panels to the metal frame with the provided bolts and screws. To maintain the pod, simply spot clean any messes that occur and avoid prolonged use >1hr.

To implement the bookshelf, attach the branches to the wall in the configuration shown. To maintain the bookshelf, dust every week and avoid heavy books on long or unsupported members.

To implement the bucket seats, put them in the classroom in the hangout area. To maintain the seats, avoid jumping our bouncing on seat. Also touch paint up whenever it may chip.

5.5 Results

In the end, we implemented a space that students could go, to not only hangout, but also to read or enjoy some quiet time. Our client was pleased with our design and appreciated our ingenuity. We were able to repurpose materials that would have likely gone to waste, which fits in with our criteria to be eco-friendly. We made bucket seats from old plastic buckets, and a beautiful tree bookshelf from plywood. These elements liven the space up and provide an inviting area for students to come during break. Also, the chalkboard is a nice addition that replaces the ancient bookshelf that once resided in that area. The pod gives students a safe space to keep to themselves and indulge in their favorite book.

Overall, our client representative and the students are satisfied with the outcome of the project and are excited to put it to good use.

Figure 5.5-A: *Painted chalkboard, bucket seats, and foam flooring.*

Figure 5.5-B: *Reading pod, foam flooring, and tree bookshelf.*

Figure 5.5-C: *Bucket seat with black and white leaf fabric.*

Figure 5.5-D: *Tree bookshelf bracketed to the wall.*

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