UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Community Service Learning Egg Carton Storage Facility Project

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University of British Columbia

CIVL 201

November 22, 2010

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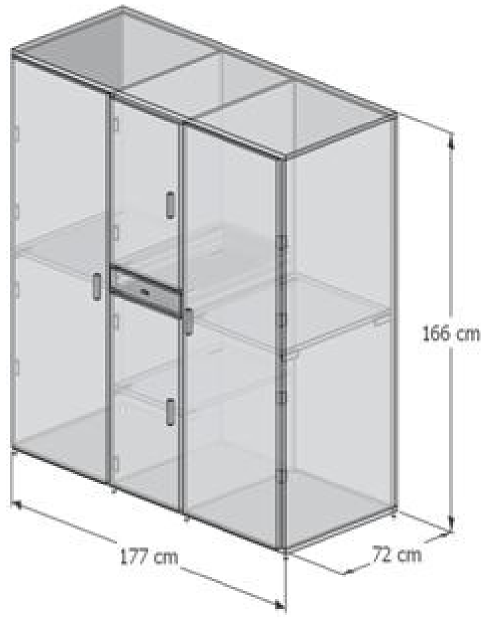
UBC Social, Ecological, Economic Development Studies (SEEDS)
Student Report



Community Service Learning Egg Carton Storage Facility Project

Cayley Van Hemmen, Christian Hajen, Rocky Zhang, Ricky Sangha, Bobby Gu, Ralph Mercado

University of British Columbia

CIVL 201 – Introduction to Civil Engineering Design

Due: November 22, 2010

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ACKNOWLEDGEMENTS

The CSL Egg Carton Storage Unit Group worked closely with several people and organizations. Without their support and assistance, the research and learning that went into the shed could not possibly have happened.

The first person we would like to thank is Mr. Haydar Sabti. He is our CSL mentor and played an important part in helping us focus on the sustainability aspect of this project. During our weekly meetings, he offered suggestions on our design and made sure we were thinking in terms of how both the client and the environment could benefit from our design.

The client for our project was UBC Farm, located just south of Fairview. The individual with whom we interacted was the volunteer coordinator, Gemma McNeill. On the first day we met, Ms. McNeill showed us the mess of unsorted egg cartons and tasked us with creating a system in which the egg cartons could be stored and without the risk of contamination from rats and bugs. Throughout the duration of the project, Ms. McNeill worked with us to produce the proposed design which we all agreed would most greatly benefit the UBC Farm. Her input and advice was valuable due to her experience on the farm in dealing with the egg carton problem.

Finally, we would like to thank Dr. Nesbit, Greg Johnson and the rest of the instructors. On several occasions, we were given advice on the design and how we were to proceed with the construction. We feel that this advice helped us think in terms of long term goals instead of short term goals. This new way of thinking brought new ideas to the table, such as environmental impact, which is an aspect of design we may not otherwise have considered.

With the help of the aforementioned parties, we were able to learn about the technical design procedure, a process that most group members had never experienced. Alone we could not have accomplished this design, which we feel will have a lasting, positive impact on the UBC Farm, the ecosystem and all six group members.

LIST OF TABLES

1.0 INTRODUCTION

This report provides a detailed outline of a proposed project plan to Ms. Gemma McNeill, UBC Farm volunteer. In order to deal with the sanitary issues created by rodents and the much needed larger storage facility for egg cartons, Ms. McNeill has requested a team of civil engineering students to design and build a portable storage unit for stacked egg cartons that is impervious to rodent urine, feces, chewing and entrance. The subsequent sections of this report include background information about UBC Farm, a scope statement for the project, and detailed information regarding the design of the storage unit. In addition to these sections, the report also contains information about scheduled activities associated with the preparation and future implementation of the project such as meetings with the client.

2.0 BACKGROUND ON UBC FARM

The UBC Farm lies just south of Wesbrook Village, comprising 24 hectares of cultivated land in UBC's temperate rainforest environment. The farm is just as much an educational facility as it is a crop producer, as children often come in groups to learn about sustainable practices including composting and organic farming. It has received praise for its ecologically friendly farming methods from organizations including the David Suzuki Foundation.

The farm has been an important part of UBC's heritage for over 80 years. It sees over 2,500 students on its grounds annually and as of recently, it has served as a place for aboriginals to practice the farming techniques used by their ancestors. In addition from being a teaching facility to people of all ages, its produce is sold and the money is donated to restaurants and campus food services. Stands filled with fresh vegetables and flowers can often be seen around campus, especially near the bookstore. Produce is also sold at local Farmer's Markets and campus food providers. The produce sold by the UBC Farm varies, but often consists of vegetables, fruits, cut flowers, edible flowers, herbs, berries, honey and even eggs. The eggs are made possible by a flock of chickens housed in the farm. A southern aspect and sandy soil make it easy to grow a variety of plants. Additionally, the recent installation of drainage tiles and a watering system ensures that plants receive the optimal amount of water. The organic farming practices used at the farm have given the farm Certified Organic Association of British Columbia status. The close proximity of the farm to water masses would otherwise contaminate coastal marine life by eutrophication and by pesticides.

The UBC farm is more than a playground for children. In the past, hundreds of research projects have been conducted at the UBC farm. Faculties ranging from Arts to Applied Science have used the farm to understand evolutionary biology, behavioral neuroscience and bio-fertilizer development just to name a few. Educational seminars ranging from learning to make beeswax candles to fermenting pickles increase public awareness of environmentally friendly alternatives to purchased goods. Being one of the largest green spaces near the UBC main campus, the farm serves as a valuable location to study animals that often reside in the area, as the natural hemlock forest has been largely preserved.

For several years, Civil Engineering students have taken part in projects aimed to satisfy a need at the UBC farm. From cable protecting blocks to egg washing stations, students have helped the farm, but have also benefited from the skills they have gained along the way such as leadership, perseverance and creativity. This year, the farm will once again benefit from second year Civil Engineering students looking to help the farm in a given aspect.

3.0 SCOPE STATEMENT

Inside a crowded greenhouse that's infested with rodents lies over 700 used egg cartons stacked chaotically on top of a small table. Covered in dust and spider webs, these disheveled egg cartons are not only a great concern due to sanitary issues but are also an appalling eyesore to the employees of UBC Farm. Thus, a group of bright and eager CIVL 201 students are put to the task of designing a new storage unit for these egg cartons and other cleaning supplies within this limited space.

3.1 Hard Goals

The main hard goals of the Sanitary Egg Carton & Supply Storage Unit project will be to create a storage unit that:

- Holds at least 700 egg cartons with room left over for cleaning supplies and recycling bins.
- Fits and operates easily within a small indoor space with dimensions of 2m in length, 1m in width and 1.7m in height.
- Is lightweight, portable and have easy access for stocking and removing cartons and supplies.
- Is impervious to rodent urine, feces, chewing and entrance for sanitary reasons.

Further hard goals are listed here specifically for each day of the build

- Day #1 (Date: TBD)
    - To assemble the foundation of the storage unit (bottom frame with attached wheels)
    - To attach the inner shelves to the interior frames and side frames
    - To assemble the framework of the storage unit (excluding the top frame, rear frame and front doors)

- Day #2 (Date: TBD)
  - To assemble and install the drawer that will be used to store cleaning supplies
  - To install the rear frame of the storage unit
- Day #3 (Date: TBD)
  - To complete the exterior framework of the storage unit by installing the top frame
  - To install the hinged doors of the storage unit

Other soft goals for this project include:

- To work as a team to overcome obstacles and solve the problem provided.
- Divide tasks among team members equally and based on individual strengths and weaknesses.
- To gain an introductory understanding of the Civil Engineering Design Process.
- To produce detailed designs using Building Information Modeling Software such as Google Sketch up.
- To compile and present all relevant information in a civil engineering technical report.

3.2 Major Constraints

The major constraints of this project include:

- A budget of only $350 to purchase necessary supplies.
- The limited amount of space we have to work with.
- The requirement that our design must hold at least 700 30cm by 30cm egg cartons.
- The design must be completely impervious to rodents.

3.3 Indicators of Success

Indicators for our group's success may include:

- Meeting all important deadlines and submission dates.

- Obtaining the approval of the board on our design.

Other indicators for our design's success may include

- Matching or exceeding the required storage capacity for egg cartons.
- Fits adequately within the space provided.
- Ease of access of egg cartons and cleaning supplies.
- Resistance to rodents.

4.0 DECISION MAKING PROCESS

4.1 Decision Making Process

The basis on which all group decisions were made was democracy. Although several members had specific roles such as Technical Drawings Coordinator, Team Leader and Team Secretary, all members actively participated in making key decisions that the group made. On any given meeting, the group leader will begin by discussing the deliverables due by the date of his choosing. Group members are then given a chance to voice their opinion with respect to the deadline and the workload. Additionally, members volunteer to write sections, which they feel they can relate well to. Democracy rules, as the Team Leader simply conducts meetings, but has no veto power over the collective opinion of the group. Therefore every member has one sixth of the decision making power of the group.

4.2 Creation of Conceptual Designs

With respect to selecting a design, all six group members were tasked with producing one high quality sketch illustrating his or her ideal design concept. This drawing was to be completed with dimensions and labels indicating which shelves contained the unsorted cartons, the good cartons, the rejected cartons, the recycling bin and the cleaning supplies. No group member was told to draw up any specific design, despite the fear that all designs would be nearly the same. It turned out that all six designs varies in dimensions, special features and visual appearance, which was of great relief. After the six designs were submitted at the meeting, each was analyzed and critiqued by all group members and of these six designs, three were chosen by the group as being the best choices for future construction. This decision was made on the basis of a Multi-Criteria Decision Making Matrix, a concept taught in CIVL 201 class. Group members unanimously selected the three most important criteria that the ideal design would have and ranked the importance of the given criteria on a subjective scale of importance. The three chosen criteria were accessibility, cost and space efficiency. Each of the six designs would then be scrutinized by the group and each design was given a score based on the fulfillment of each of the three criteria. When the "importance coefficient" of the criteria was multiplied by the "fulfillment score" and all three criteria were summed up, a numerical score was given to each design concept. The three concepts with the highest score were then to be presented to the client, along with a brief description of our number one choice and why it received the highest score. The design with the highest score belonged to Ricky. His front-loading shed featured an integrated slide out recycling bins and efficient use of shelving to organize unsorted cartons, cleaning supplies and sorted cartons. The criterion which was given the most weight was accessibility and this happened to be the strongest attribute of Ricky's design.

4.3 Multi-Criteria Decision Matrix

Directly below is a table that analyzes in detail the three chosen designs for the Multi-Criteria Decision Matrix, Furthermore, the selection rational is described in detail what conditions we considered each design, Finally a summary of results is provided at the bottom, with our decision that design #2 was most appropriate.

Design Number:	Amount of stacked egg cartons that can be stored (# of egg cartons)	Total cost of the materials required to build the storage unit (in $)	Assessment of the proposed storage unit's accessibility and portability (no units)
Design #1: **Dual Sided Design**	The proposed storage unit's shelves are very well organized. The design addresses the client's interest in designating extra space for recycling bins and cleaning supplies. The	The proposed storage unit contains lots of shelves. Hence, this design requires lots of plywood; however, this is remedied by the fact that supplies such as plywood can	This particular design would likely be very portable because of the 4 wheels that permit easy movement. Furthermore, the storage unit is able to fit through the door. Sliding doors

	division of the storage unit into 2 sides may reduce the amount of egg cartons that can be stored. The spacing proposed by the design enables the storage unit to store up to 1000 egg cartons.	be salvaged from the UBC Plant Operations Warehouse. Other than that, wheels, sliding doors and rollers have to be purchased to build the storage unit. Projected Total Cost = $ 340	provide ease of access to individual shelves on one side; however, since it is designed to have 2 sides, it may be difficult to stock and remove egg cartons due to the small indoor space. (Please refer to the Conceptual Designs and Decision Making Process section of the technical report for a more detailed explanation.)
<u>Design #2</u>: **Single Sided Design**	The proposed storage unit's shelves provide lots of space for vertical stacking of egg cartons which make stocking and removing of cartons easier. The design addresses the client's interest in designating extra space for recycling bins and cleaning supplies. The spacing proposed by the design enables the storage unit to store up to 1200 egg cartons.	Most of the proposed storage unit will be made out of plywood. This is not a problem as such supplies are provided. Hinges for doors and wheels for rollers have to be purchased to build the storage unit. Projected Total Cost = $ 337	The storage unit has 4 wheels which permit its movement when necessary. In addition, it is able to fit through the door. The storage unit is designed to be one sided to ensure easy access for the stocking and removal of egg cartons in a small indoor space. (Note: Hinged doors are used instead of sliders because of the tendency of sliders to degrade over time.)

Design #3: Top Loading Design	The proposed storage unit's shelves are organized. The design addresses the client's interest in designating extra space for recycling bins and cleaning supplies; however, the dimensions of the proposed design limit the amount of egg cartons that can be stored by the storage unit. In particular, with a height of 1 meter, this storage unit stores about 700 egg cartons at best which is acceptable but not ideal.	This design would be very cheap to build because there will not be many components needed aside from plywood, paint and about 6 hinges. Projected Total Cost = $ 220	The storage unit is rigid and stationary. In addition, accessibility could be an issue due to the fact that egg cartons at the bottom of the stash will be very difficult to reach and sort out. The storage unit is designed to be one sided to provide easier access for stocking and removing of egg cartons in a small indoor space as opposed to a dual sided storage unit.

Selection Rationale:

Note: Please refer to the Conceptual Designs and Decision Making section of the technical report for more information.

a.) Criterion #1 (Space Efficiency):

The space efficiency of the storage unit must be taken into account to meet the client's expectations of storing 700-800 egg cartons. Designating extra space for 2 recycling bins and cleaning supplies is preferable. More importantly, the limited indoor space available imposes constraints that must be taken into account by each design.

b.) Criterion #2 (Projected Total Cost):

The cost effectiveness and total money spent to build the storage unit also plays a role in determining the overall success of the project. Since the majority of the supplies such as plywood can be salvaged from the UBC Plant Operations Warehouse, it seems very unlikely that the cost of building the storage unit will exceed the allotted budget of $350 for miscellaneous materials. For this reason, the criterions of space efficiency, accessibility, and portability are more important.

c.) Criterion #3 (Accessibility and Portability):

The client expects the storage unit to provide easy access for the stocking and removal of egg cartons and cleaning supplies in a small indoor space. For this reason, its accessibility and portability are significant factors that must be taken into account.

- The table below indicates the methods used to calculate the indicator values of each design for a specific criterion.

Calculation of Indicator Values for Criterion #1: Normalized # of egg cartons	5*(γ-α)/(β-α) where α = 700 egg cartons (least amount of egg cartons that can be stored), β = 1200 egg cartons (highest amount of egg cartons that can be stored), and γ = # of egg cartons that can be stored by the current option.
Calculation of Indicator Values for Criterion #2: Normalized Projected Total Cost	5*(γ-α)/(β-α) where α = $ 340 (most expensive option), β = $ 220 (cheapest option), and γ = projected total cost of the current option.
Calculation of Indicator Values for Criterion #3:	Each option is rated out of 5 based on the

Subjective Assessment of Accessibility and Portability	features of the proposed storage unit's accessibility and portability.

Design Number:	Design 1: Dual Sided Design	Design 2: Single Sided Design	Design 3: Top Loading Design
Criterion 1	Space Efficiency	Space Efficiency	Space Efficiency
Crit. indicator (include units)	Amount of space available to store stacked egg cartons and cleaning supplies (# of egg cartons)	Amount of space available to store stacked egg cartons and cleaning supplies (# of egg cartons)	Amount of space available to store stacked egg cartons and cleaning supplies (# of egg cartons)
Crit. 1 Indicator Value (See explanation below)	3.00	5.00	0.00
Normalized or Subjective:	Normalized	Normalized	Normalized
Weighting Factor	3.5	3.5	3.5
Total	10.50	17.50	0.00
Criterion 2	Projected Total Cost	Projected Total Cost	Projected Total Cost
Crit. Indicator (include units)	Total cost of the materials required to build the storage unit (in $)	Total cost of the materials required to build the storage unit (in $)	Total cost of the materials required to build the storage unit (in $)
Crit. 2 Indicator Value (See explanation below)	0.00	0.13	5.00
Normalized or Subjective:	Normalized	Normalized	Normalized
Weighting Factor	2	2	2
Total	0.00	0.25	10.00
Criterion 3	Accessibility and Portability	Accessibility and Portability	Accessibility and Portability
Crit. Indicator (include units)	Assessment of the proposed storage unit's accessibility and portability (no units)	Assessment of the proposed storage unit's accessibility and portability (no units)	Assessment of the proposed storage unit's accessibility and portability (no units)
Crit. 3 Indicator Value (See explanation below)	3.50	4.00	4.50
Normalized or Subjective:	Subjective	Subjective	Subjective
Weighting Factor	4.5	4.5	4.5
Total	15.75	18.00	20.25
Site Totals	26.25	35.75	30.25

Summary of Results:

Criterion Name:	Design #1: Dual Sided Design	Design #2: Single Sided Design	Design #3: Top Loading Design
Space Efficiency	10.50	17.50	0.00
Projected Total Cost	0.00	0.25	10.00
Accessibility and Portability	15.75	18.00	20.25
All Decision Makers Total:	26.25	35.75	30.25

- Most Ideal Design proposed to the client: Design #2 (Single Sided Design)

4.4 Selection of Conceptual Design

The ultimate decision of which design was selected lay in the hands of our client at UBC Farms. After the three top designs were selected, it was the role of Christian, Bobby and Rocky to meet with Gemma to discuss the design which would most greatly fulfill the needs of the UBC farm. The volunteer coordinator-Gemma- critiqued our 3 designs while we discussed the advantages and disadvantages of each of the unique designs. It resulted that she particularly enjoyed the front-loading design that had been produced by Ricky. This design consisted of recycling bins incorporated into the structure, which was to be very convenient for the staff working on the egg cartons. The consensus was that Ricky’s design was to be slightly modified, with changes to the depth of the shed and the number of shelves it supported. Gemma also proposed a top-loading unit, where a piece of plywood on vertical track sliders would rise up to facilitate loading into the bin. Most group members did not favor this idea due to the fragile nature of the sliding track and the lack of room in which to store the cartons. Despite the reluctance of group members to pursue the idea of the top-loading system, Bobby was given the task to draw up a schematic diagram for the design that Gemma had proposed. After Ricky and Bobby had updated and perfected the drawings, they were sent to Gemma. When she replied, she inquired as to the design of sliding door system as well as the design of the sliding track on the top loading system. Ricky and Bobby answered the questions on their respective designs. At this point, members were beginning to doubt that the front-loading system- the one that we were pushing- would be approved by Gemma, who seemed to favor the top-loading system.

4.5 Adjustments to Initial Design

After careful thinking as a group we were able to determine possible flaws and the fixes for these flaws in out front loading system. One concern had been that sliding doors would not be very efficient in the long run, as they would wear down over time making it difficult to open them. Therefore we decided it would make more sense to have simple doors that open on hinges to cover the unit. The only reason we did not do this at the beginning was because of limited space to open the doors, however Gemma later clarified that certain things could be moved in order to accommodate space to allow the doors to open free of obstacles. Another concern was that the front loading system may not be able to hold enough egg cartons, some group members thought it would be best to change our design and abolish our original plan of integrating recycling bins into the unit. This would allow the unit to hold much more egg cartons, however Gemma really seemed to like the idea of have recycling bins for easy access included in the design. They would be very convenient for workers while sorting the egg cartons. We therefore decided it was best to put them in but make the bins and the shelves that hold the bins to be removable, thus the client would be able to “modify” the unit based on their needs at any specific time. For example if they a lot of clean egg cartons, they would be able to remove the bins and shelving and use this extra space to store clean cartons or other supplies. Most of our group members agreed that this would the best approach to the problem so we once again sent the revised front loading system design to Gemma. This time the results were different, Gemma seemed very pleased with the design and gave it an approval to be submitted as a part of our final report.

4.6 Material Selection

An equally important attribute of the storage unit will be its eco-friendliness. Being an organic farm, UBC Farm wanted a product that was representative of their views on sustainability. For this reason, the group was given a tour of the farm including the plywood and wood beams (including 2x4s and 2x8s) available to us. Based on our observations, we set a goal to use as much reusable wood as possible in the construction, thus reducing waste of usable wood and therefore reducing the need for more trees to be felled and for money to be spent unnecessarily. As long as the wood is not used by another group, it is our expectation to produce a shed composed of up to 70% recycled materials. The materials we cannot procure enough of- likely plywood- will be purchased from companies who harvest in the least environmentally sensitive areas of the province. A list of materials that will be used in the project is included below:

Item	Name	Amount	Price
A	200 cm X 80 cm X 2 cm plywood sheets	8 pieces	Provided by UBC Farm
B	100cm X 50 cm X 2 cm plywood sheets	6 pieces	Provided by UBC Farm
C	200 cm X 180 cm X 2 cm plywood sheet	1 piece	Provided by UBC Farm
D	50 cm X 10 cm X 2 cm plywood sheets	2 pieces	Provided by UBC Farm
E	70 cm X 10 cm X 2 cm plywood sheets	2 pieces	Provided by UBC Farm
F	80 cm X 70 cm X 2 cm plywood sheets	2 pieces	Provided by UBC Farm

G	Cabinet Wheels	8 pieces	($3/piece)(8 pieces) = $24
H	Big Hinges	12 pieces	($10/piece)(12 pieces) = $120
I	Wall Brackets	25 pieces	($7/piece)(25 pieces) = $175
J	Screws	75 pieces	($3/pack) (1 pack = 100 pieces) = $3
K	Door Handles	4 pieces	($3/piece)(4 pieces) = $12
L	Drawer Handle	1 piece	($3/piece)(1 piece) = $ 3
M	Sandpaper	-	Provided by UBC Farm

Total Cost = $24 + $120 + $175 + $3 + $12 + $3 = $337
Allocated Budget = $350

Note: Using nails to attach frames and shelves can be considered as an alternative to reduce the overall cost of building the storage unit. In particular, if UBC Farm is unable to provide all of the plywood sheets required to build the storage unit, then nails will be used rather than wall brackets to spend a portion of the budget to purchase plywood sheets.

List of Tools:

Item	Name
A	Band Saws or Table Saws
B	Screw Guns
C	Tape Measures
D	Router
E	Paint Brushes
F	Hammers
G	Safety Glasses

4.7 Life Cycle Assessment

Thinking about the future of the project we also considered the fact that this storage unit may need to be removed or demolished. Since the unit is to be put together using screws, it would be very easy and convenient to disassemble it and recycle the wood. Therefore the wood would be in excellent conditions so it may be later used by other CSL groups on their projects. This further helps us attain our goal of implementing sustainability concepts into our project.

5.0 FINAL DESIGN RATIONALE

5.1 Criterions of Selection

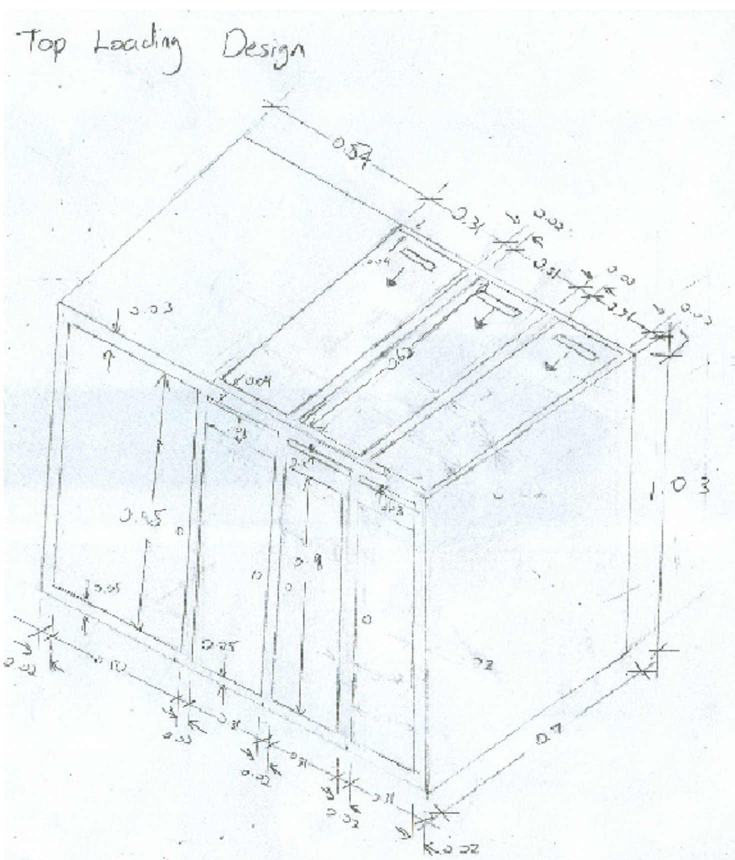
After taking account of the conditions of the greenhouse, the indoor space available, the cost and other constraints, the group decided that the three most important criterions that our design must conform to are accessibility, cost and space efficiency.

Cost was determined to be the least important of these aspects because of the abundant availability of free raw construction materials including plywood and paint that are provided by UBC Farm. Thus, it seems very unlikely that the cost of building the storage unit will exceed the allotted budget of $350 for miscellaneous materials. For that reason, it was only given a weighting factor of 2 out of 10 in our Multi-Criterion Decision Making Matrix analysis. Cost for the designs will be accessed quantitatively based on the amount and cost of the materials required.

Space efficiency was the next most important constraint because the storage unit must fit within a tight space of about 2 meters in length, 1 meter in width and 1.7 meters in height. Additionally, the storage unit must be able to fit through a tight door space of dimensions 0.84m wide by 2.13m high. With these constraints, we must also ensure that our design will hold at least 700-800 egg cartons that are 30cm by 30cm in width and take up about 1.0 cm each in height when stacked on top of each other. Furthermore, it would be preferable if the storage unit will also have space to hold 2 recycling bins and other cleaning supplies. Overall, this criterion was given a weighting factor of 3.5 out of 10 in the MCDM Matrix analysis. The space efficiency of conceptual designs will be assessed quantitatively based on how many egg cartons it could hold, the amount of space available for cleaning supplies and how well it will fit within the allotted space provided.

Accessibility and portability were decided to be the most important criterions of the conceptual designs. The reason for this is because the clients expect the storage unit to provide easy access for the stocking and removal of egg cartons and cleaning supplies. Furthermore, the other two criterions (space efficiency and cost) will only affect the initial design and construction phase of the project while on the other hand, accessibility and portability will be a prominent factor when our project is actually being used by the client to solve the problem. Thus, it was given a weighting factor of 4.5 out of 10 on the MCDM Matrix analysis. They will be accessed subjectively by analyzing how easily the egg cartons and supplies can be accessed and how portable the designs are.

5.2 Top Loading Design



This design was originally suggested by Gemma McNeill who believed that it would maximize the egg carton storage capacity of the unit within the allotted space.

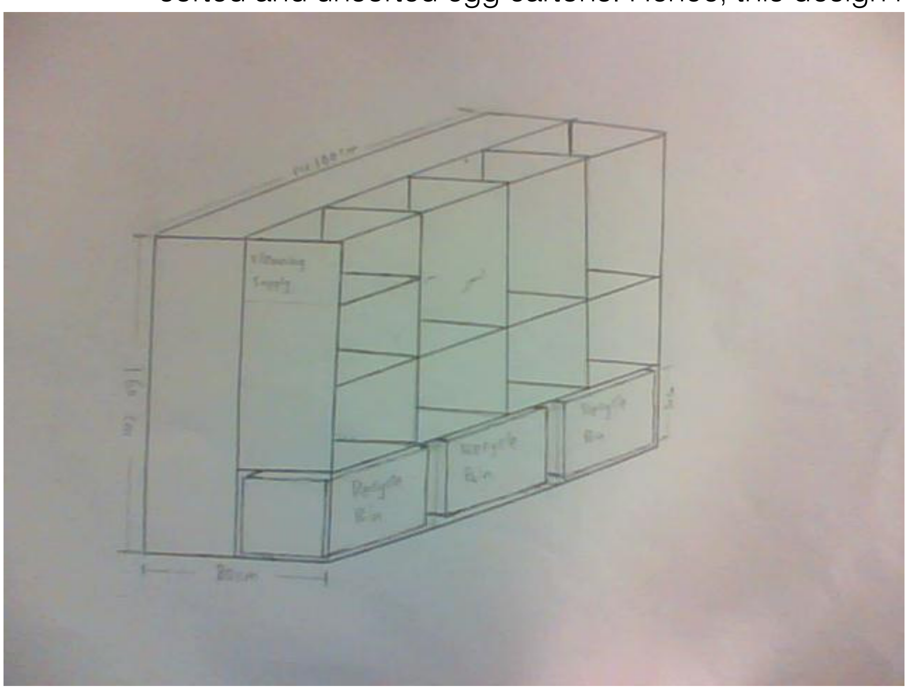
After analyzing the conceptual design, we noted that it would be very cheap to build because there will not be many components needed aside from plywood, paint and about 6 hinges.

However, although this design is space efficient, the fact that someone would have to bend over the top loading portion to deposit the egg cartons is a major constraint to the maximum allowable height of the design. With a height of 1 meter, this storage unit stores about 700 egg cartons at best which is acceptable but not ideal. Furthermore, the egg cartons may not stack perfectly when loaded into the compartment which is rather inconvenient.

Another major downside of this design includes its lack in portability because it is rigid and stationary. Furthermore, it also lacks accessibility because the egg cartons at the bottom of the stash will be very difficult to reach and sort out. For these reasons, this was not our recommended conceptual design to the client.

5.3 Dual Sided Storage Shed Design

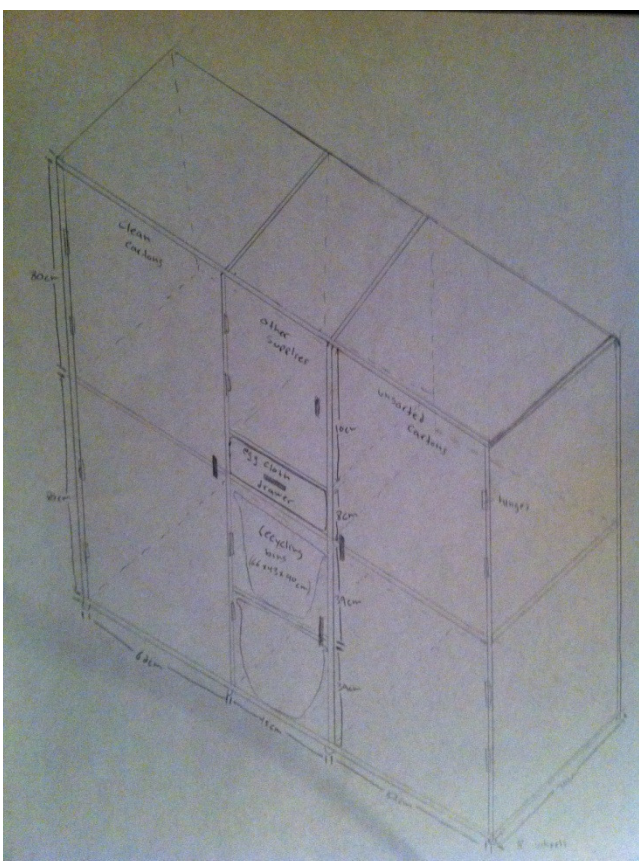
This proposed storage unit contains shelves that provide ease in separating sorted and unsorted egg cartons. Hence, this design requires lots of plywood; this problem is partially remedied by the fact that supplies such as plywood can be salvaged from the UBC Plant Operations Warehouse. Other than that, wheels and rollers would need to be purchased for the rollers and sliding doors. However, it seems unlikely that the projected budget will be exceeded.



In terms of storage capacity, the proposed storage unit's shelves are very well organized and effectively use of all the provided space available. Overall, it is calculated to be capable of storing up to 1000 egg cartons. Furthermore, the design addresses the client's interest in designating extra space for recycling bins and cleaning supplies. However, the division of the storage unit into 2 sides may render one side to be unused because of inconvenience due to limited indoor space.

This particular design would likely be very portable because of the 4 wheels that permit easy movement. Additionally, sliding doors provide ease of access to all compartments. However, wheels and rollers tend to degrade in effectiveness over time because of debris that may get caught within the components. Since the storage closet is relatively massive, it may be very difficult to actually switch from one side to another because of the space constraints. Thus, the other side will be very inaccessible in this small indoor space. For these reasons, this conceptual design was not recommended to our client.

5.4 Single Sided Storage Shelf Design



Similar to the other designs, the majority of the structure will be constructed out of plywood which can be salvaged from the UBC Plants Operation Warehouse. Other than that, the only other materials required will be the hinges for doors and wheels for rollers. Thus, cost will not be much of an issue.
In terms of storage capacity, the proposed storage unit's shelves provide sufficient amount of space for vertical stacking of egg cartons which make stocking and removing of egg cartons easier. Similar to the double sided design, it addresses the client's interest in designating extra space for recycling bins and

cleaning supplies. The spacing proposed by the design enables the storage unit to store up to 1200 egg cartons and the excess space is a huge advantage.

In terms of accessibility, this design has 8 wheels that permit minor movement when adjustments are needed. Although they may degrade over time, it won't be as big of an issue as in the double sided design since the need for movement would not be as frequent in this case. Additionally, it is designed to be one sided to ensure easy access for stocking and removing of egg cartons in a small indoor space. Furthermore, hinged doors are used instead of sliders because of the tendency of sliders to degrade over time. For these reasons, we unanimously decided that this would be the most ideal design and recommended it to the client.

5.5 Client's Final Choice

After discussing our conceptual designs with our client, the single sided storage shelf design was accepted after making a few minor adjustments. It was preferred because of its excellent storage capacity, its lightweight and portability and the ease of access to all compartments.

6.0 SUSTAINABILITY OF THE PROJECT

As with nearly all construction projects both large and small scale, there are both benefits and repercussions to the environment. The goal of constructing an effective egg carton storage shed is to make as small an ecological footprint as possible, while greatly benefitting the operations at UBC Farms. The most obvious negative impact to the environment that most projects present is the materials requirement. A typical wood-built residential house in Vancouver requires in excess of two logging trucks of uncut logs (QueryCat, 2010). After cutting the logs must be transported, cut to size, packaged, shipped to the distribution facility and then shipped to the construction site. For every process, carbon dioxide is released through the use of equipment. Scaled down to the construction of a wooden shed, the principle is much the same. Every bit of wood that is reused saves trees from being cut and transported.

When considering the materials to construct the shed, one of the top priorities was to use as little "new" wood as possible. Materials from the farm such as plywood and beam wood (2"x4" beams) would account for 70% of shed construction materials, thus greatly reducing the impact of the shed on the environment. In addition to the reuse of materials, it was of equal importance to avoid the use of harmful chemicals. Though aesthetically pleasing, paint contains many chemicals and solvents that are highly toxic. Such chemicals can and often do leech off the paint if left out in the rain. Being such a sensitive ecological area, one drop of the hydrocarbon-based chemicals can poison up to one million drops of groundwater. In addition to the risk of groundwater contamination, the evaporation of solvents during the drying process emits the solvent vapors into the air, thus polluting it. For these reasons, the shed will not be painted, glazed or chemically sealed in any way. To prevent infiltration by mosquitoes, natural wax-based or otherwise non-toxic sealants will be injected into the seams to provide a secure closure at any joint in the shed.

Inevitably, the shed will present some drawbacks, although it is the goal to minimize such drawbacks and ensure that the benefits greatly outweigh them. As previously mentioned, although we wish to use up to 70% previously used lumber, we expect to need pieces not available at the farm. If this is the case, we will purchase wood from environmentally responsible logging companies. Such logging companies will use policies such as selective logging in environmentally sustainable areas instead of clear cutting in sensitive areas. Finally, to ensure that the materials used in the construction of the shed may be reused, we will use galvanized screws and angled metal joints to connect the pieces of plywood. Using galvanized screws allows both the screws and the wood to last for a long time without rusting as most nails would cause if left in the rain. This way, in 5 years if the needs of the UBC Farm change, they may take apart the shed and reuse the pieces, thus maintaining the cycle and all the while maintaining the ecological footprint of the UBC Farm as small as possible.

7.0 DAY-BY-DAY BREAKDOWN

7.1 Day One

Time	Activities	Reminders
8:30am – 9:30 am	• Meet at UBC Farm • Brief review of the desired goals for the day • Get the tools and equipment that are provided by UBC Farm • Divide into 2 groups • Assign tasks to each group	• Bring all of the materials that were acquired prior to the three day build • Bring proper attire, gloves, and safety glasses
9:30 am – 12:30 pm	• Measure and cut plywood sheets for the side frames and inner shelves (group 1) • Measure and cut plywood sheets for the bottom frame and interior frames (group 2) • Attach 8 wheels to the bottom frame using screws (groups 1 and 2)	• Provide assistance to the other group (if necessary)
12:30 pm – 1:15 pm	• 45 minute break (Lunch)	• Bring your own food and drinks
1:15pm – 5:00 pm	• Attach the inner shelf (on the left side) to the side frame and interior frame (group 1) • Attach the inner shelf (on the right side) to the side frame and interior frame (group 2) • Attach the components produced above to the shelves that are designated for recycling bins (groups 1 and 2) • Attach the bottom frame to the structure that is composed of shelves, side frames, and interior frames (groups 1 and 2) • Clean up	• Frames and shelves are attached to each other through the use of wall brackets and screws. • Provide assistance to the other group (if necessary)

	• Return all tools	

7.2 Day Two

Time	Activities	Reminders
8:30 am – 9:30 am	• Meet at UBC Farm • Brief review of the desired goals for the day • Get the tools and equipment that are provided by UBC Farm • Divide into 2 groups • Assign tasks to each group	• Bring proper attire, gloves, and safety glasses
9:30 am – 12:30 pm	• Measure and cut plywood sheets for the top frame (group 1) • Measure and cut plywood sheets for the rear frame (group 2) • Measure and cut plywood sheets for the drawer's components (groups 1 and 2) • Make a 1cm deep cut in the sides of the drawer (groups 1 and 2)	• Provide assistance to the other group (if necessary)
12:30 pm – 1:15 pm	• 45 minute break (Lunch)	• Bring your own food and drinks
1:15pm – 5:00 pm	• Assemble the drawer using wall brackets and screws (groups 1 and 2) • Attach the drawer handle to the drawer • Attach a 6 cm X 2 cm X 1 cm plywood sheet to the left side of the interior frames (group 1) • Attach a 6 cm X 2 cm X 1 cm plywood sheet to the right side of the interior	• The rear frame will be attached to the storage unit through the use of wall brackets and screws. • Provide assistance to the other group (if necessary)

	frames (group 2) • Insert the drawer while ensuring that the 6 cm X 2 cm X 1 cm plywood sheets slide into the cuts in the sides of the drawer • Attach the rear frame to the storage unit (groups 1 and 2) • Clean up • Return all tools	

7.3 Day Three

Time	Activities	Reminders
8:30am – 9:30 am	• Meet at UBC Farm • Brief review of the desired goals for the day • Get the tools and equipment that are provided by UBC Farm • Divide into 2 groups • Assign tasks to each group	• Bring proper attire, gloves, and safety glasses
9:30 am – 12:30 pm	• Measure and cut plywood sheets for the doors on the sides (group 1) • Measure and cut plywood sheets for the doors in the middle section of the storage unit (group 2) • Install door handles to all of the storage unit's doors (groups 1 and 2) • Install mouse proof seals (groups 1 and 2)	• Provide assistance to the other group (if necessary)
12:30 pm – 1:15 pm	• 45 minute break (Lunch)	• Bring your own food and drinks

1:15pm – 5:00 pm	• Attach the top frame to the storage unit (groups 1 and 2) • Attach hinges to all of the storage unit's doors (groups 1 and 2) • Clean Up • Return all tools	• The top frame will be attached to the storage unit through the use of wall brackets and screws. • Provide assistance to the other group (if necessary)

8.0 ROLES AND RESPONSIBILITIES

8.1 UBC Farm (First Term)

In the first semester, Ms. Gemma McNeil was UBC Farm's Representative and acted as the client for the egg carton storage facility project. The group met with her multiple times to discuss the overall design for the project as well as project constraints. She provided the group with her input and approval of designs through email as well as oral communication. Her role was to provide guidance, state her needs, the farm's needs and the necessities required in the design.

In the second semester, Ms. Gemma McNeil will again act as the representative for UBC Farm and oversee the construction of the project. She will be providing us with the following recycled materials courtesy of the farm: 8 sheets of plywood 6'x4', an abundance of 2x4s, 2x6s and other thin pieces, aluminum brackets and mesh or varying size, paint, basic work tools, screws, hinges, etc.

8.2 The Team (First Term)

Vital to the team's success was having defined roles for each group member. Everyone assumed his or her roles appropriately and in a professional matter. Due to this, all assignments were completed at a very efficient and productive rate. Furthermore, each individual was able to give one another feedback regarding design related issues. In the first semester, each member was given the following roles:

8.2.1 Team Leader

Christian Hajen was assigned the role as the team leader due to his excellent communication skills and motivational personality. His job was to be the primary contact with Ms. McNeil as well as our team mentor, Haydar. His task also entailed forwarding meeting minutes to the team secretary, as well as making important delegation decisions. Every weekly Thursday meeting Christian would assign each member a task to be completed by the next meeting.

8.2.2 Team Secretary

Cayley Van Hemmen was assigned the role as team secretary due to her organizational abilities. Her job entailed taking meeting minutes at every meeting, filing of all of the paperwork produced from the project and assembling the final draft of the formal report.

8.2.3 Technical Drawings Coordinator

Rocky Zhang was assigned the role as the technical drawing coordinator. This position entailed learning the basics of Google SketchUp to produce a professional technical drawing for the formal report.

8.2.4 Other Team Members

The jobs of other team members were to each complete a rough draft technical drawing, collaborate their ideas to create a MCDM for the decision making process and well as complete various tasks relating to the creation of the formal report and record keeping assignment.

8.3 Team Members (Second Term)

In order to ensure that the project will be implemented successfully and completed on time, the entire team will be divided into 2 groups during the three day build. Specific tasks will be assigned to each group to ensure that the objectives for each day of the project's implementation are fulfilled. For each of these three days, all team members must acknowledge their roles and responsibilities in order to accomplish the tasks of both groups. The roles and responsibilities of each team member during the three day build are listed below.

Roles and Responsibilities of every team member:

- Arrive on time
- Bring proper attire, gloves, and safety glasses
- Follow safety requirements
- Be cooperative and helpful during the construction process
- Provide assistance to other groups when necessary

→ Please refer to the "Scope Statement" section of the technical report for the list of the objectives for each day of the three day build.
→ Please refer to the "Three Day Build Schedule" for more information about the tasks assigned to groups 1 and 2.

8.4 UBC Farm and SEEDS (Second Term)

In order to complete the tasks associated with the implementation of the project, UBC Farm and SEEDS must take on certain roles and responsibilities to provide assistance to our team during the project's implementation.

Roles and Responsibilities of UBC Farm and SEEDS:

- Provide materials and tools that are available
- Answer questions that the group may have regarding the project

9.0 RISK ASSESSMENT

There are many risks involved in carrying out the assembly of a small storage space construction project and can be collected into the following categories:

9.1 Construction Risks

As this project is strongly construction based in the implementation, various tools will be used to construct the design. Power tools are extremely dangerous if not used properly. Some power tools that will be required for this project include drills for inserting screws, a router to hollow out wood, saws to cut the wood, and an electric sander to finish the wood. Some possible incidents could include personal injury through misuse. Many hand tools are required for this project as well, including hammers, screwdrivers, levels, dividers, mauls, jacks etc. Although less dangerous than power tools, individuals must exercise the same caution while using them. Possible incidents could include bruising/injuries from misuse of hammer or through misuse of a maul.

Injuries are also likely to occur during construction of the project due to the fact only two members of the group, Cayley and Ricky have experience in a construction environment. Therefore, caution should be exerted at all times by all members to prevent these incidents from occurring. The members with experience will also watch over others to help prevent accidents. Without all the members present during the construction process, the project will not be able to be completed on time. To prevent this, the group has made a schedule on doodle so all members can be present during building. Also, power tool incidents are more likely to occur if the members with tool experience are not present.

As UBC Farm is providing us with recycled wood for the project, much of it has already been used. Without a thorough investigation and analysis of the materials, incidents may occur during construction and/or use. For example, the wood could split at the fibers or cutting planes if not properly inspected before use.

After implementation and completion of the project, the group must test the design so incidents will not occur after construction. Weight testing and moving tests must occur to ensure a safe design. A thorough investigation is necessary to provide a useful and practical design for the client. By having each member of the group inspect the design in detail, loose screws, nails, and broken wheels can be spotted and fixed before presenting the final design to the client for use.

9.2 Maintenance Risks

The group's goal for the project was to create a storage device for UBC farm that would be able to be used over a long period of time. However, there are many outside factors that can weaken a newly implemented design in an untested environment. Some of these risks include rodent infestation and corrosion of hinges and nails.

The group researched rodent infestation and concluded that a strong, sturdy design with a door and no other area of entry to the design would be sufficient to keep rodent infestation at a minimum. This possible scenario was kept in mind throughout the design process, thus maintenance regarding rodents will not be necessary due to the unlikely nature of the event occurring.

In regards to nail and hinge corrosion, the group researched into buying non-corrosive nails for the project. However, as they are quite expensive, it was quickly decided this design aspect needed to be sacrificed. As the storage shed is kept in a relatively dry environment, hinge and nail corrosion should be minimal.

Thus, as the storage facility is a very low-risk design as it uses a minimal amount of materials and maintenance checks will not have to be done very often. Thus, only a yearly check over the storage shed will be necessary to keep it functioning efficiently. The only high priority maintenance will be for the shed to be cleaned every month with a quick rinse from a high powered hose. This will prevent rodents from having any desire to enter and gnaw at the storage shed, thus allowing it to be used for many years to come.

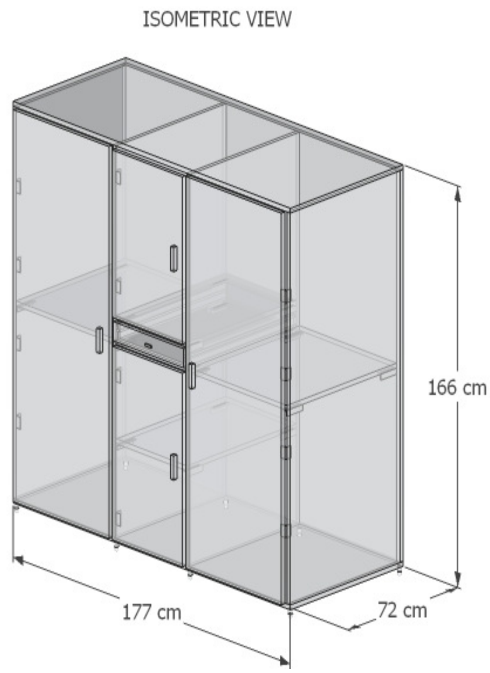
10.0 CONCLUSION

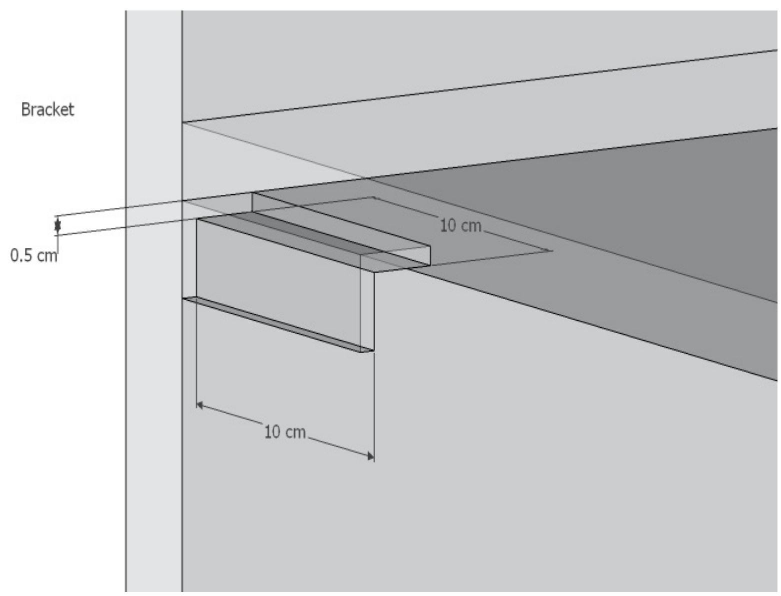
This report has outlined the detailed design of a working storage unit as well as the construction process needed to fully execute this design. However, as thorough as this report is, the design and construction process is likely to change minutely during the implementation of the project at UBC farm due to unavoidable factors such as weather and materials that are allotted to the group. Other than this, the group believes the project will not have any other areas of concern and can be successfully implemented for under $340 and provide the client with all of the necessary requirements for the problem proposed.

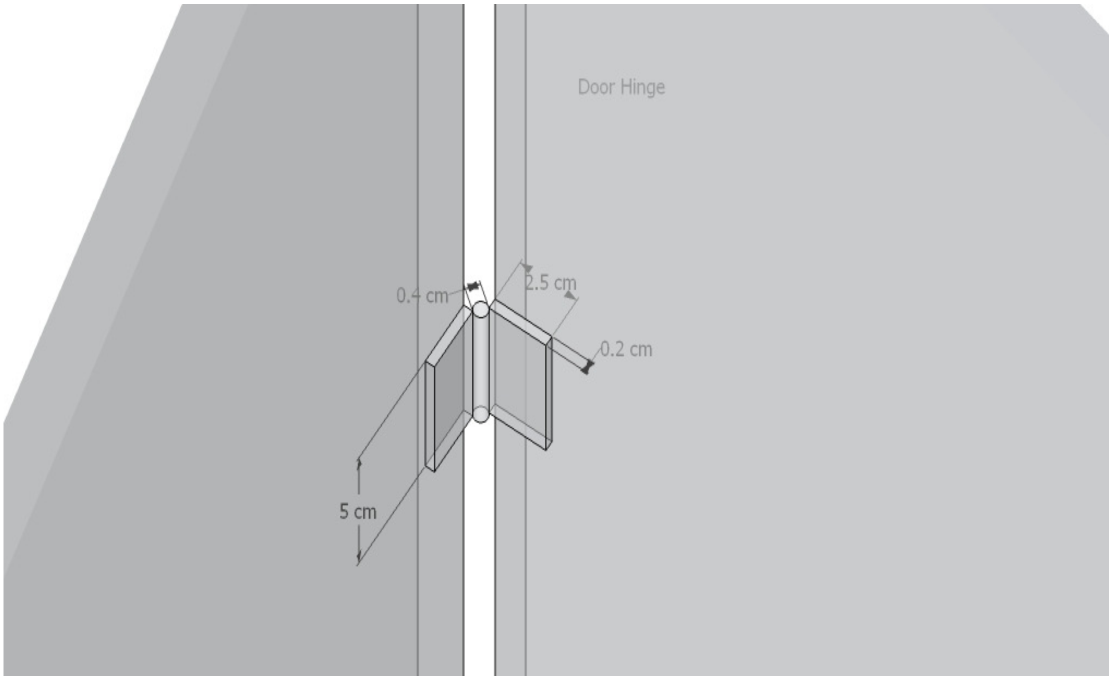
The project group in its entirety wants to see a successful build of the design proposed in the project. After a long and thorough decision making process which included extensive communication with the client, Gemma McNeil, the group believes their final design is extremely appropriate to the situation present at UBC Farm. As it stands now, the current storage facility in use at UBC farm is incapable for holding over 800 egg cartons as well as including a storage facility for recyclable materials. The design presented resolves all the problems presented and meets all the needs necessary, provided excess space for the egg-cartons to be stored, as well as extra storage areas for cleaning supplies.

In conclusion, many hours have gone into the research, planning, and design of the project, and thus the group hopes it is goes above and beyond expectations for the client's needs.

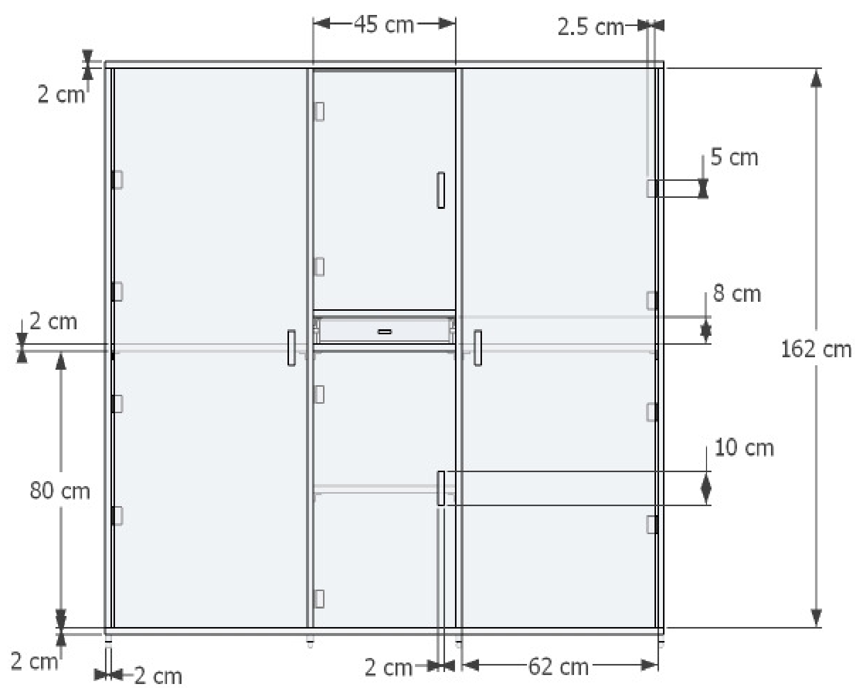
APPENDIX A: LIST OF TECHNICAL DRAWINGS



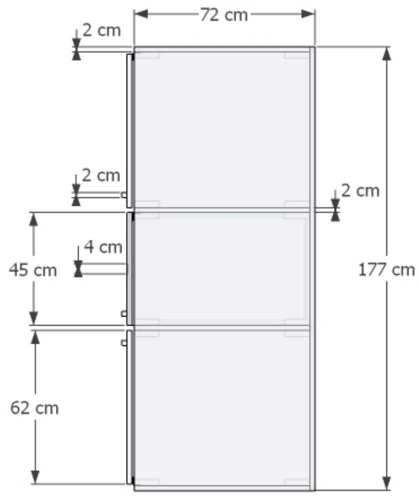




ELEVATION VIEW



PLAN VIEW



SIDE VIEW