Developing Weight Estimation Method for Habitat for Humanity ReStore Metro-West/ Greater Worcester

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Abstract

The Habitat for Humanity ReStore collects and sells donations of housing materials. Grants are required to increase the efficiency of business. For grants, ReStore needs an efficient method of weight estimation for items kept from landfills. This project determined that method and how to implement it. This project required (1) immersion into the ReStore, (2) data collection, (3) analysis of methods, and (4) education based on these methods. ReStore should reconfigure its current database and implement the estimation method.

Executive Summary

The Habitat for Humanity ReStore MetroWest/ Greater Worcester is a branch of the non-profit organization, Habitat for Humanity, and receives unused or partially used housing materials as donations from individuals, local retailers, and other businesses. It then resells the materials at 50 -75% below retail prices and donates its proceeds to Habitat for Humanity. In this way, the ReStore benefits the environment by preventing a significant amount of materials from being sent to the landfill. It also benefits the community by providing quality and highly affordable building materials to the public.

The ReStore needs grants in order to improve its donation processing system. The ReStore needs a method to estimate the tonnage of materials that it keeps out of landfills as it is essential in applying for such grants. Unfortunately, having a floor scale permanently cannot be a solution for estimating tonnage because not only the space the scale will occupy is necessary for donations but constantly collecting weights will slow down the overall donation process.

Therefore, the goal of our project is to develop an estimation method to determine the actual tonnage of materials that are sold at the ReStore. This will consequently facilitate ReStore in applying for the grants necessary to improve the current system of donation processing. The project objectives are:

1. Site assessment
2. Data collection
3. Comparison of weight estimation methods
4. Manual implementation

We spent a week at ReStore as volunteers in order to get insights on how ReStore runs and how our project could be integrated into its working environment. After obtaining information during the first week, we started to collect data samples. We collected a thousand data points and created a database based on them; we analyzed our data and derived a formula to estimate the tonnage; and we compared our formulas to find out the more accurate one. Finally, we created a manual that contains step by step instructions on how to utilize the weight estimation method and how to update the database in future. In addition, we also had training session for administrations to demonstrate our method.

Based on the information we can get from the ReStore sales report, we designed two different method for weight estimation. One is based on the average weight of each department

and the other is based on the average sales price of the items in each department. Also, the ReStore currently implements the idea that for every dollar that is sold, 1.3 lbs. of material are kept out of the landfill in order to estimate weight. We tested and compared the monetary value and weight methods to the ReStore's current weight estimation method in order to fully evaluate which method is more accurate.

After the best possible method is determined, the administration will be in charge applying this method to their own database. At the end of each month, a report is taken from the database at the ReStore that outlines the departments, total sales by department, and the quantity of items sold in that month. What we have determined through our calculation is the department weight average and the department conversion factor.

These values are used to estimate weight in two different methods. The weight estimate based one average weight is fairly simple. The estimated weight of a department is calculated by multiplying the department average weight and quantity of sold items. When this calculation is done for every department, the sum of the products is the total weight of items sold during that particular month. The weight estimation based on monetary value uses a similar process. The department weight conversion factor is multiplied by the total sales of that particular department. Since the weight conversion factor has the units of pounds per dollar, when it is multiplied by dollars, a weight estimate is derived. This is done for each department as well. Finally the sum of all of those estimates equals the total weight of items that were sold during that month.

Lastly, we compiled some recommendations for the ReStore to take into consideration. In order to increase the efficiency of future data creation, we recommend that the ReStore change the database systems it currently has in place. Furthermore, to avoid the discrepancy present when placing an item in a department, the ReStore needs to clarify how to classify donations in departments. In order to increase the overall accuracy of the average weights and conversion factors for each department, it is necessary for ReStore to accumulate more data in the future and obtain a larger sample size to reduce the chance of errors. Finally, the ReStore should adhere to the steps we have provided for them estimate the tonnage of materials the ReStore keeps out the landfill.

Acknowledgments

To all that have helped us accomplish our task, we would like to express our gratitude for your contributions. We would like to acknowledge specifically our sponsor, Debora Maruca Hoak, for her unyielding effort to ensure that we delivered the best possible product to the ReStore.

We would also like to thank Louis Garcia and Gary Dietrich, along with all volunteers and employees, for offering their experience and knowledge of the ReStore to aid us in collecting data for our methods. They were instrumental in making sure that our efforts were efficient and productive during donations processing.

Lastly, we would like to thank our advisors Angel Rivera and Robert Traver for their contributions to our project. They provided us with exemplary guidance, constructive feedback, and a challenge that tested our talents in our endeavors. Thank you to all and we wish you the best in your further success and future accomplishments.

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1. Introduction

The Habitat for Humanity ReStore MetroWest/ Greater Worcester has a need of grants in order to improve the donation processing system. Applying for grants requires the ReStore to estimate the tonnage of materials that it keeps from the landfill. However, the ReStore currently does not have such system to estimate the tonnage. The following proposal will aid the resolution of the issue.

Habitat for Humanity, a non-profit organization, was founded in 1965 by Millard and Linda Fuller. Habitat for Humanity's mission is to build houses for those who are in need ("The history of Habitat", n.d.). Their organization has expanded over decades and now Habitat for Humanity is a world-wide organization that has aided in building more than 800,000 houses by 2013 ("An amazing accomplishment", n.d.). In order to support Habitat for Humanity's mission, the Restore, a housing material retail store, donates its profits to the corporation.

The ReStore receives unused or partially used housing materials as donations from individuals, local retailers and other businesses. It then resells the materials at 50 -75% below retail prices. In this way, the ReStore benefits the environment by preventing a significant amount of materials from being sent to the landfill. It also benefits the community by providing quality and highly affordable building materials to the public. However, the ReStore lacks a system for weight estimation, a problem that inhibits it from applying for grants.

The goal of our project is to develop an estimation method to determine the actual tonnage of materials that are sold at the ReStore. This will consequently facilitate ReStore in applying for the grants necessary to improve the current system of donation processing. First, we became acquainted with the ReStore's work environment. Based on our observations, we designed a method to collect weight samples and create a database. Using this database, we have estimated the tonnage of donations. Finally, we have established metrics and protocols for future estimation and database update and teach administration to utilize our deliverables.

2. Literature Review

The purpose of this chapter is to provide a deeper understanding of background information necessary to support our goals and objectives. In this section we profile our sponsoring agency, Habitat for Humanity MetroWest/Greater Worcester ReStore, and identify its primary stakeholders. The chapter also explores best practices for methods of weight evaluation and how other organizations assign value to donations. We evaluate the possible methods of database creation. Finally, we consider case studies to learn how others have approached similar problems.

2.1 Habitat for Humanity MetroWest/Greater Worcester Restore

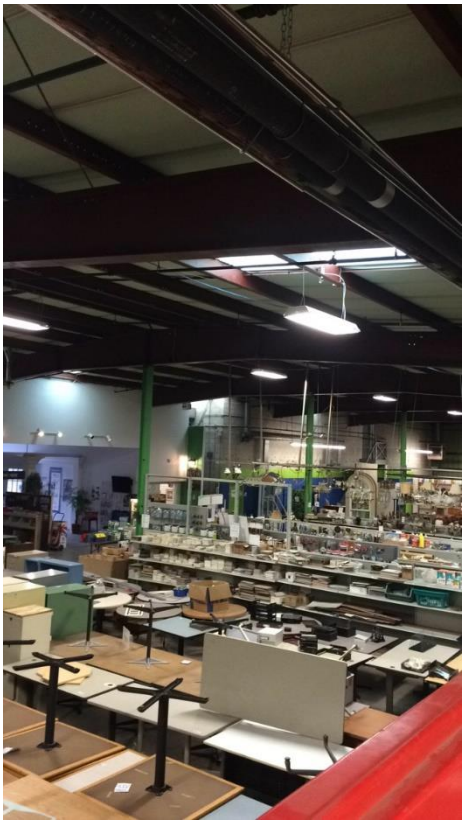

Figure 1: ReStore MWGW Sales Floor
Photo Credit: Ken McPherson 1/22/15

Habitat for Humanity Worcester Restore is a branch of a global, charitable organization called Habitat for Humanity International (HFHI). HFHI's mission has been to put Christian values into action by building homes and communities since the organization's founding in 1976 (Hays, 2002).

Millard Fuller, the founder of Habitat for Humanity, believed the most critical responsibility of Habitat for Humanity is to eliminate substandard housing around the world. The organization believes that housing is supposed to be built in partnership with those in need. Thanks to large numbers of volunteers that work with Habitat for Humanity, the recipients' costs of building houses substantially decrease (Hays, 2002). Thus, the slogan of Habitat for Humanity is "A hand up, not a handout" ("About Us - Habitat For Humanity MetroWest/Greater Worcester," n.d.).

Massive donations and a volunteer labor force staffed by individuals and organizations have helped those less fortunate to improve substandard housing by selling homes at below market values to eligible families. The ReStore is a unique outlet store that collects donated goods and

resells them at a heavily discounted rate. The revenues from the donation sales are then used for home building efforts ("Mission & Vision," n.d.).

2.2 Key Stakeholders

The ReStore depends on the donors to provide it with merchandise. The donors use the Restore as a method to remove unwanted items without throwing them away. Many volunteers also work at the ReStore to transport donations in and out the building ("At the Restore," n.d.). Our project has the potential to affect the current work environment of the organization by adding other elements of work for the volunteers such as improving and managing the database we will provide.

The ReStore donates all proceeds to Habitat for Humanity. If grants were given to the ReStore, it is possible that Habitat for Humanity could see greater efficiency and an increase in profits that could be put towards building more houses.

2.3 Estimation of the Weight of Materials

Other agencies have found ways to estimate the weight of sold items. The simplest way is to simply multiple the quantity of items present by a single items weight.. For example, when a stack of 3x4x8 bricks needs a weight estimate and all that is given is the number of bricks the and weight of one brick, the estimate is simply the weight of one brick multiplied by the number of bricks present. The "Recycle Bowl Competition" has dealt with this problem using the following steps:

1. Identify the volume of materials present
2. Identify the unit weight of material
3. Track the data ("Recycle-Bowl Competition," n.d.)

Other organizations estimate weight and volume on a regular basis. Landscaping and construction companies use and evaluate materials based on weights. However, this does not work for all materials. The Broadmoor Landscaping Supply made available their bill of materials and showed that only some materials are categorized by weight ("Broadmoor Landscaping," n.d.). For example, many materials were sold by the pallet or by volume of the material and not the weight. However, the weight of donations kept from the landfill is what the ReStore desires. The ReStore sells much more than just building material, including home furnishings and home improvement

materials ("About the ReStore," n.d.). The donation process of the ReStore can be modified to allow for the weight estimation of these materials. In order to better understand the donation process, other organizations' methods can be taken into consideration.

2.4 The Donation of Processes at Comparable Organizations

The Salvation Army has been accepting donations since 1865 ("HISTORY," n.d.). However, its donation process is different than that of the ReStore. Salvation Army assigns monetary values to donations right away and has a range of values based on the shelf life or the condition. Its donation value guide shows a wide variety of donation categories, similar to the ones we are working with ("The Salvation Army Family Stores," n.d.). The ReStore's value guide shows how many items were sold and the average sale price (Figure 1). The Salvation Army's value guide shows a range of prices for each donation. By applying the range scale that the Salvation Army has been using, we could find a way to value our items and extrapolate the tonnage from the amount sold in the previous week.

Sales Summary - Sales By Department -

Dept	Total $ Sold	Avg Sale Price	Sum # Items Sold
Furniture	$1,507.84	¤35.90	43
Doors/Windows	$368.00	¤26.29	20
Decorations	$260.68	¤4.42	159
Building Materials	$141.45	¤7.07	57
Electrical	$218.38	¤5.60	52
Paint	$108.25	¤5.70	44
Hardware	$69.58	¤1.93	82
Tools	$88.85	¤2.17	73
Kitchen	$102.54	¤20.51	5
Media	$19.42	¤0.63	153
Plumbing	$61.00	¤30.50	3
Appliances	$50.00	¤50.00	1
Bathroom	$35.70	¤7.14	13
Flooring	$37.00	¤12.33	3
Gardening	$35.00	¤35.00	1
Lumber	$17.71	¤1.48	48
Other	$16.50	¤2.06	13
Soda	$8.45	¤1.41	9
Donation	$10.73	¤0.49	22
	$3,625.52		**801**

Figure 2: Weekly Summary of Sales (Hoak, D (2014))

Goodwill follows a similar methodology. It accepts a wide variety of donations that fall into departments similar to the ReStore's ("Valuation Guide for Goodwill donors," n.d.). In fact, all three organizations share similar protocols. The main difference is that the ReStore has a much wider range of prices of donations than the other organizations. A wider range of monetary value per department makes estimating the price the item was sold at more difficult. Without a proper method to evaluate the sales price of each item, the weight estimates extrapolated from the sales price will be less accurate. We can identify procedures, problems, and potential solutions that may aid the ReStore by studying the methods of other charitable organizations. Once we have a proper method of weight estimation, we can start to collect a sample.

2.5 Sampling Data

Since we have to sample weights, we needed to research different methods of data sampling in business. The most common types of sampling used in business are: simple random sampling, stratified random sampling, and multistage sampling. Simple random sampling consists of taking a random sample from a data set. An example of this is pulling names out of a hat. Stratified random sampling consists of dividing the data set into different subgroups and then taking a random sample from each subgroup. A real world example would be in a census survey. The census board would divide the US into states, and then take samples from random cities in that state. Lastly, multi-stage sampling consists of several levels of strata within a data set. For example, when a sample is being taken from the population of the United States, different levels of strata that might include states, cities, and even sections of those cities. This kind of data sampling performs best with a sample that is going to be compiled into larger groups ("Parker, M," n.d.). Since weights of items in ReStore may vary significantly depending on what they are, we will adopt stratified random sampling. We will divide the whole pool of donations into subgroups, or departments, and compile samples taken from each subgroup.

2.6 Database Creation

Our team will ultimately implement a database management system so that the ReStore can track the materials accumulated in another study similar to this one. Some examples of

database management systems include network databases, hierarchical databases, and relationship databases. These databases differ greatly in how they present data. In order to understand the full potential of network, hierarchical or relationship tables, we need to discuss the relationships these tables implement in order to present data.

A "one-to-one" relationship is when each row in a database table is specifically related to another row in a different database table. "One-to-many" relationships are when each row in a table can have a connection with many rows in another table. "Many-to-many" relationships are when one or more rows in a table can be related to one or more rows in another table ("Table Relationships", n.d.).

A network database management system is a system that relies on utilization of a set construct. This system was defined in 1971 during the Conference on Data Systems Languages. A set construct consists of many different record types and member record types; these are usually subsections of record types. Usually these types of databases display mainly one-to-many relationships but it is possible for one member record type to belong in the subsection of many record types resulting in many-to-many relationships. Rarely will a network database management system result in a one-to-one relationship ("Database Models", n.d.).

A *hierarchical database management system* organizes its data in a "tree structure" ("Database Models," n.d.). This data system was popular in the late 1960's because of the introduction of IBM's Information Management System database. Resembling a family tree, this type of database relies on implementing a 1: N relationship where N can be any number of data, details, or facts. One data point on a hierarchical database can branch off into many different subunits and those subunits can then branch off even more ("Database Models," n.d.).

A relationship database management system is a system in which a table is formed in order to store and maintain data. Data can then be connected to the data in other tables by common concepts. A relationship database management system uses a specific language referred to as Structured Query Language. This language is used to perform specific commands, such as queries, which can potentially change the database ("A Relational Database Overview," n.d.). Some examples of relationship database management systems are Microsoft Access, Filemaker, and MySQL ("A List of Database Management Systems", n.d.). This is the type of database

management system best suited for use in our project to manage the data collected. We will produce a one-to-one relationship where the weight of the item is directly related to the item.

2.7 Selected Case Studies

In this section, we discuss two specific case studies related to our project. The first case is chosen because it involves weight estimation of construction materials and implements a statistical method. We plan on utilizing several different ideas drawn from this study. The second case describes an analytical method for weight estimation that compensates the drawbacks of statistical method. Even though the method described in the second case was not feasible for our project, we decided to examine this study so that we could adopt some aspects of it.

Case 1. Estimating Building-Related Construction and Demolition Debris Amount

In order to have a glimpse of how weight estimation is performed, we examined a report on weight estimation of building-related construction and demolition (C&D) debris published by United States Environmental Protection Agency (EPA). The report focuses on the estimation of the amount of building-related C&D materials generated and recovered in the US during 2003.

In this study, national statistical data and typical waste generation rates are used to estimate the weight of C&D materials. The C&D waste is classified into six different categories: residential and nonresidential construction, residential and nonresidential demolition, and residential and nonresidential renovation. A common method is applied to each of the categories with a variation in calculating some variables. First, the average C&D debris generation rate for a type of activity is calculated by utilizing data from various research groups. Each data set includes the site area and the total waste generated during the activity. The total waste generated is divided by the area of the activity site; the average weights per square foot are then averaged again. The final average value is the typical weight of debris per unit area generated during that activity and can be used to calculate the weight of debris generated, which is represented by the product of the area, in square feet, of the activity and the average waste generated per area, in pounds per square foot, for the activity type. The reason for using weight rather than volume when estimating the amount of waste is that the weight of materials remains constant throughout their lifecycle while the volume might change due to compaction or other processing. Utilizing this methodology, approximately 170

million tons of building-related C&D materials were estimated ("Estimating 2003 Building-Related Construction and Demolition Materials Amounts", 2009).

In particular, the non-residential activities involve a greater variety of materials; this means that the method for the average waste generation described above becomes less accurate. From this fact, an estimation will be less accurate as each category of sold goods includes a greater variety of items made from different raw materials. This points out the importance of effective categorization of items.

In its introduction, the report acknowledges the presence of some level of uncertainty in the estimation due to a lack of data. Basically, we will establish the foundation for an effective weight estimation method for the ReStore. Therefore, we will not have enough data for the most accurate estimation. The report confirms the limitations of a statistical estimation: our estimation at the end of the project would not be the most accurate.

Case 2. Analytical Weight Estimation of Landing Gears for Airplanes

The second case features an analytical weight estimation of airplane landing gears. The estimation algorithm is thoroughly described in a project completed by Virginia Tech students. Their work first discusses the shortage of statistical methods and appropriateness of their estimation and proceeds to the details and algorithms of the method.

Statistical weight estimation is incapable of responding to variations in different landing gear designs. As landing gear designs have changed over time, the equation based on past designs has becomes obsolete. However, analytical estimation is able to consider the variations such as "length of strut, material ultimate strength, vertical load, and number of tires" ("Weight Estimation", n.d, p.72). The analytical estimation consists of five procedures: defining gear geometry, calculating applied loads, applying the loads into each structural part, sizing cross-sectional areas, and calculating component and total weight. Basically, the analytical estimation breaks a landing gear into several pieces according to their geometry and estimates the total weight as the contribution of all the parts. After breakdown of the whole system, seven different loading conditions are considered and their effects are applied. Then, the weight of each part is calculated based on the analysis done in previous steps and the material density. Finally, the summation of all the part weights is the total weight of the landing gear ("Weight Estimation", n.d).

We deduced from the report that the analytic estimation is far more accurate than statistical one when estimation includes objects of various materials and designs. Since the items in the ReStore are not consistent in their designs, this analytic method can provide more accurate result than statistical one. However, setting up the criteria for every type of items in the ReStore is not feasible for our project.

We then tried to study the case's methodology in a greater scope so that it can applied to our project. In order to improve the credibility of estimation, we consider dividing the whole system into subsystems by certain characteristics. We will utilize and modify the list of categories of donations that already exist to break down the whole estimation process. By defining subcategories, we will be able to increase the accuracy of the estimation.

2.8 Summary

In our investigation, we were able to build a foundation of knowledge related to our problem. Our review of the literature revealed 4 key points: we have begun to understand the organization, its history, mission, and current objectives. We also evaluated the donation processes and weight estimation processes of other organizations. Among the different types of databases and sampling methods, we determined that a relationship database and stratified random sampling would best satisfy our goals. By conducting case studies, we learned that other agencies have conducted similar cases that are helpful in our own methodology. They provided insight into how we break down our objectives as well as how to collect data. All of this research will prove to be instrumental in our methodology.

3. Methodology

Our goal was to create, test and teach a method of weight estimation to determine the tonnage of materials brought into the ReStore so that it can utilize this information to apply for future grants. To meet our goal, our objectives and a brief description of our methods are presented here:

1. Conducted a detailed site assessment
    a. Worked with volunteers and administration to better understand how the ReStore manages donations processing and sales
    b. Understood how volunteers contribute to the donation process through observational studies
    c. Interviewed members of ReStore about their current work environment
2. Collected samples
    a. Outlined and integrated the process of weighing into the donation process
    b. From donations, we acquired their weights, sales price, and department designation
3. Compared weight estimation methods
    a. Created database
    b. Evaluated best weight estimation method
4. Formulated protocols
    a. Created a manual to assist future data collection processes
    b. Trained employees how to update database and troubleshoot

3.1 Objective 1: Conduct a detailed site assessment

During the first week of our project, we conducted a participant-observation study by volunteering at the ReStore. This form of data collection allowed us to examine and determine nonverbal expressions such as feelings, determine how volunteers and employees interact and check the time it takes to complete an activity (Kawulich, 2005). We learned what it is like to be a volunteer at the Restore, how the Restore generally runs on a typical day, and how volunteers contribute to the overall function of the ReStore. In order to gain further knowledge on the ReStore, we conducted interviews (questions found in appendix A) of the ReStore's employees and most frequent volunteers. The staff provided us with a detailed idea of the Restore's work environment

and perspective on how our recommendations can affect the ReStore as a whole. After getting accustomed to the climate and procedures of the ReStore, we proceeded with our data collection.

3.2 Objective 2: Collect Data

Our methods of weight estimation are heavily dependent on the average weight and average sales price of each department. Therefore, our major data points that were collected from each donation are the weights, the sales price, and the department the donation is designated to. Since a floor scale was provided to us, we were able to easily extrapolate the weights of donations. We were able to derive the sales price and department designation through the guidance of employees working in the donations processing area. The location of the floor scale was advised by the employees as well. It lied in the "fixing area" because of its central location between the two avenues in which items were donated and had easy access to the sales floor (Figure 3). Because of the distraction created from us collecting data, we needed an efficient way to integrate data collection into donations processing.

We decided that a team of 3-4 members was best to accomplish this task. We designated one member of the team to be the data recorder. Their job was to read off the data points once they were collected from each donation. They were located near the floor scale. The other members had the job of acquiring donations to be analyzed. They either moved donations coming into the ReStore into the data collection area or went out onto the sales floor and brought donations back to the data collection area. Once donations were ready to be measured, data was extrapolated and the donations were moved to the sales floor. This process relied heavily on the employees working for donations processing so constant communication was necessary to work in an efficient manner. Once we had all of our data, we moved forward into database creation and the comparison of two methods of weight estimation.

3.3 Objective 3: Compare Weight Estimation Methods

Using the departments the ReStore currently uses in Objective 2, we designed our database. The data that were collected from weighing out all the different materials were inputted into a Microsoft Excel worksheet as Microsoft Excel is the better program when it comes to storing large amounts of data ("Microsoft Access versus Microsoft Excel for Data Analysis and Reporting, n.d.).

We will record the item weight, the department the item falls in, a description of the item and the price of the item. This file then was imported into Microsoft Access as this software is better at formatting large amounts of changing data that can be utilized by multiple users ("Using Access or Excel to manage your data.", n.d.).

We then configured the database in Microsoft Access to update automatically. When new data is imputed into the database, Microsoft Access will automatically calculate the average weight, average price and the conversion factors for each department. To avoid of damage or loss of our database, we utilized numerous methods including flash drives and the "Compact and Repair" function in order to protect our database.

During our time at the ReStore, we will test two methods of weight estimation. The first is estimating by average weight. This average will change over time while we have the floor scale but will be more accurate as our sample size becomes larger. When our time is over with the floor scale, we will have our averages to make a weight estimation. Volunteers will be able to count the number of items in each department donated and be able to extrapolate a weight estimate through this formula:

$$\text{Total Weight Estimation for a Department} = \sum [Department\ Average\ Weight \cdot Number\ of\ Items\ Sold]$$

We will test the accuracy of this formula by taking a small sample of donations, using the formula to find our estimation, and then finding the actual weight of the sample using the floor scale. This analysis will be used to compare to the accuracy of the other method we are testing.

Using monetary value is another method of weight estimation. At the end of each month, the ReStore gets a sales report with the total dollar's value sold from each department. We will create a direct, proportional relationship between the total price of items sold and the weight of donation. This relationship will be our weight conversion factor for each department and will be used, along with the total sales price of that department, to calculate the total weight of that department. The equation for this formula looks like below:

$$\text{Total Weight Estimation for a Department} = \sum [Department\ Conversion\ Factor \cdot Total\ Sales\ Price]$$

We compared our conversion factor to the conversion factor that the ReStore currently has in place which is 1.3 lbs. to $1 ("Restore," n.d.). In order to accomplish this task, we found the conversion factors for all the items sold based on the original price and based on the sold price not only to test the accuracy towards the 1.3 but also to test if the conversion factors form a trend that moves toward 1.3.

We then tested each method for accuracy. In our database, we took a small sample of donations. Each method was tested with a sample size of five donations from each department. In total, we had eighty-five donations to test our methods on. In comparing our weight estimate with the actual weight of the donations, we calculated a percent error for each method. We repeated this process three times with different donations for a more concrete analysis.

In order to test whether the data we collected during February represented data collected throughout the year, we compiled sales data from 2014, 2013 and 2012 that the ReStore had used in the past. These reports, generated each month, were used to determine if the month in which we collected data was representative of years past. We compared the sales of February 2014 to February 2013, and 2012. After, we compared the sales of February of each year to the sales of that entire year. We decided that if the sales of February and the entire sales of its respective year were proportional in some way, then we could infer that February 2015 was representative of the entire year. Therefore, we could say that our methods of weight estimation were even more accurate because of how they relate to the total sales of each year hereafter.

3.4 Objective 4: Formulate Protocols

We produced a manual for those who want to update or utilize the database. This manual includes steps on how to utilize our methods in order to estimate a department's average weight as well as procedures for updating the database. We included detailed instructions for troubleshooting by listing steps to solve several problematic situations that might occur in the future. Bulleted procedures and graphics are included to create an intuitive and easy-to-follow manual.

After completion of the manual, we trained the ReStore's current employees how to use the best method of weight estimation, how to update the database, and how to troubleshoot. Through these steps, we intend to integrate our method into the donation process.

3.5 Project Timeline

Figure 2, below, shows the estimated work plan for 7-weeks project.

	Task Name	Start Date	End Date	Duration
1	**Learn about the ReStore**	**01/15/15**	**02/07/15**	**24**
2	Work as volunteers	01/15/15	01/24/15	10
3	Analyze existing data	01/21/15	02/07/15	18
5	**Collect sample weights**	**02/01/15**	**02/28/15**	**28**
6	Weigh items	02/01/15	02/27/15	27
7	Input data	02/02/15	02/27/15	26
8	Set up the formulae	02/15/15	02/27/15	13
9	Troubleshoot	02/17/15	02/28/15	12
10	Finalize the result	02/27/15	02/28/15	2
11	**Collect sample weights**	**02/15/15**	**02/28/15**	**14**
12	Part I - Procedures	02/15/15	02/22/15	8
13	Part II - Troubleshooting	02/21/15	02/28/15	8
14				

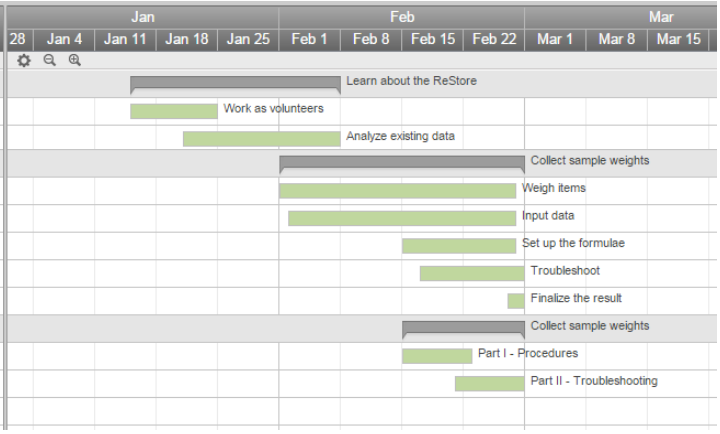

Figure 3: Project Timeline

4. Findings

In this section, we will outline our findings in regard to each of our objectives. In each section, the objective is stated and the findings that pertain to each objective are prefaced with their origin.

4.1 Site Assessment

The findings that we developed from Objective 1: *Conduct a Detailed Site Assessment* arose from the volunteer experiences and the interviews during the immersion week. They primarily result from our conversations with administration, employees, and frequent volunteers and the day to day operations of the ReStore.

In order to organize donations the ReStore receives, the ReStore currently uses 17 departments in place that an item can be classified into. Employees can help us collect data as they primarily control the flow of donations. We are able to weigh donations between 9:30 AM and 5:00 PM Tuesday through Saturday. Saturdays are the busiest days in terms of sales and donation processing. Often, donations brought into the ReStore are sold the same day. This requires us to collect data at a rapid rate. ReStore has historically used a method of weight estimation that uses a weight conversion factor of 1.3 lbs. to $1 ("Restore," n.d.). This conversion factor needs to be compared to the conversion factor we evaluate in order to test its accuracy. The database system currently in use cannot be modified which reduces the efficiency of our data collection. The ReStore offers a variety of discounts based on how long the item remains in the store and who buys the item knowing the sales price of an item becomes pertinent to our data collection. In most cases, donations come through either the unloading dock or the donation center (as indicated in Figure 4) and are taken to the sales floor through the opening in between the two sites. This indicates that the best location for the floor scale is as indicated in Figure 4.

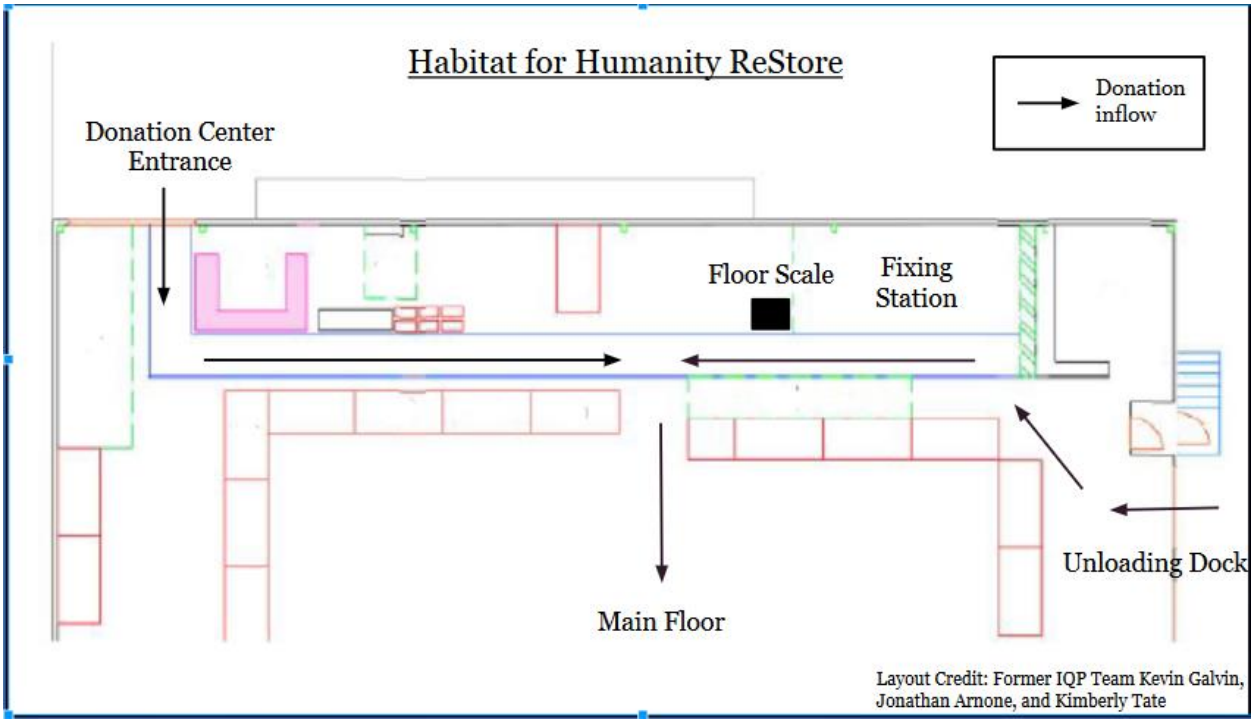

Figure 4: Inflow of donations in ReStore

4.2 Data collection

The findings related to the Objective 2: *Collect Data* include the necessary data points and other details about the data collection process. These came from the observations on donation and sales process.

The data points we need to collect are an item description, the weight of the donation, the date when the item is received and sold, the original price of the donation (before discounts), the sales price of the donation (after discounts), the department the donation belongs to. It is less convenient to use the barcode number since it does not directly appear on the sales report. Therefore, it is necessary to use an extra indicator to keep track of items previously weighed. There is a discrepancy of understanding between different employees regarding classifications of departments. This presents a challenge in classifying donations. Donations coming in during the data collection period are not various enough due to seasonal difference. Depending solely on items donated during this period will not let us to have sufficient amount of data for each department. There is a need for taking items that are already on the floor.

4.3 Estimation Method Comparison

The findings we developed from Objective 3: *Compare Weight Estimation Methods* came from running different tests and comparing the results. We utilized our methods and compared it to the actual values to determine the most accurate method. We also analyzed past sales data that the ReStore had. We were able to find out whether the collected data is representative.

First, in order to validate the accuracy of two methods, we randomly chose five items (a sample) from each department. We used two methods to estimate the weight of those items. Then, we compared and calculated percent errors of the two estimates and the actual weights of the samples. The results are shown in Figure 5. By looking at this graph, it is shown that the weight method has a less than or equal percent errors to those of the price method. From this information, it can be concluded that using item average weights to estimate the tonnage is more accurate.

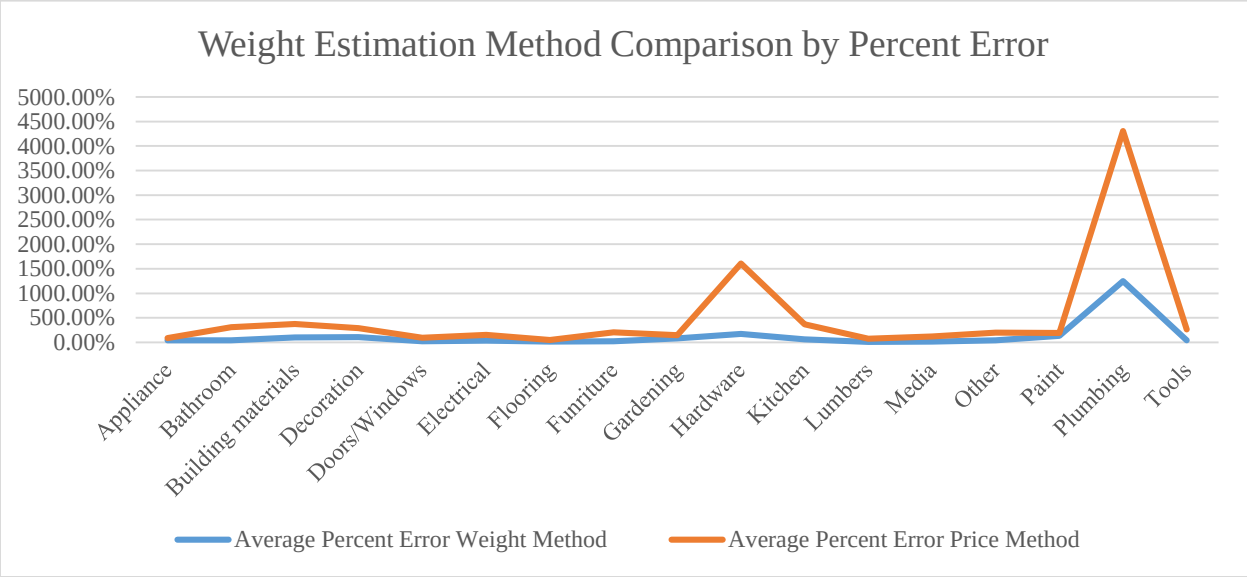

Figure 5: Weight Estimation Method Comparison by Percent Error

After graphing the information on the sales distribution of February 2014 to that of the average of the sales distributions of other months in 2014 (Figure 6), we concluded that our data collected during February does in fact represent sales of the other months in the year.

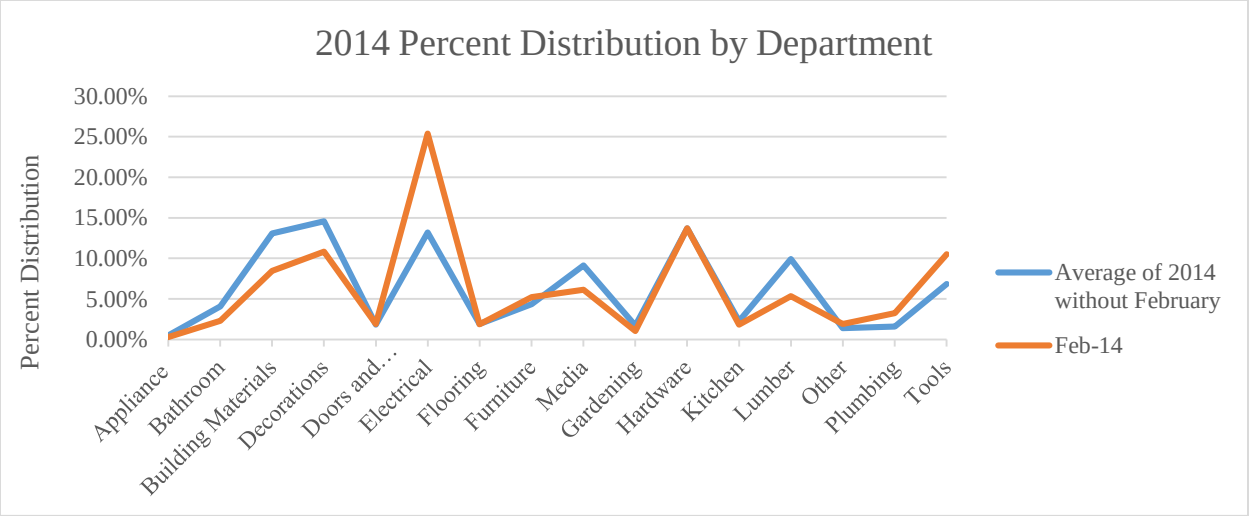

Figure 6: 2014 Percent Distribution by Department

We compared the sales distribution of February 2014 to those of February 2013 and 2012. The graph in Figure 7 shows that the sales that occur during Februarys are relatively consistent. Therefore, our methods are predictably accurate for years to come.

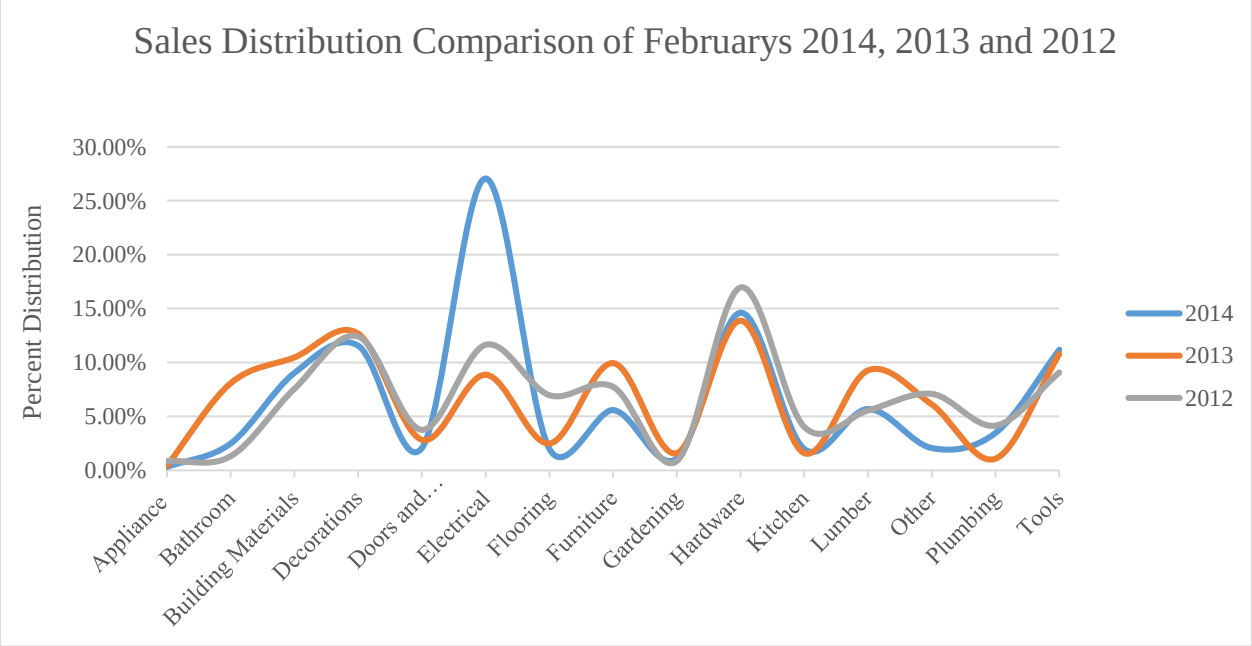

Figure 7: Sales Distribution Comparison of Februarys of 2014, 2013, and 2012

4.4 Protocol formulation

The findings we developed from Objective 4: *Formulate Protocol* came from the communication style of the employees discovered during immersion. Employees, especially donations associates, seldom use email or read memos. Therefore, a manual is the best form of communication. The actual manual can be found in Appendix B. Our method we designed is simple and efficient. The teaching session will be short and concrete. The ReStore Director will be in charge of overseeing the use our method. Also, knowing that our manual will have a section for troubleshooting, it is expected that we will not have covered every possible issue despite best efforts.

5. Recommendations

Based on our observations and analysis, we provide a method to estimate the tonnage of materials kept from landfill. While working with ReStore, we encountered some obstacles. We elaborated our findings and listed recommendations that will help ReStore achieve more accurate estimations and thus position it more compatible in its pursuit of grants.

5.1 Utilize manual

In order for our method of weight estimation to be as effective as possible, following the instructions is essential. The manual attached in this document outlines exactly how to use the method. In a clear and concise manner, it expresses the mathematical process in which a weight estimate is derived. The manual also outlines how to update our database. The database backs up our findings. The manual describes common issues in these processes and how administration can troubleshoot. During our time at the ReStore, troubleshooting was occasionally required. Those and other instances are in the manual as well as solutions for each issue. This ensures that our method will be used effectively. The manual is the tool that should be used to produce an accurate weight estimate.

5.2 Future improvements

5.2.1 Update weight database

In order to have the most accurate average weights or conversion factors for each department possible, it is necessary to update the databaseof weights, as shown in Figure 8, provided to the ReStore. During our time at the ReStore, only a small sample of yearly donations were added to our database. Therefore, in order for the database to become representative of the tonnage of material, more data is necessary. Specific instructions on how to update the weight database will appear in the manual.

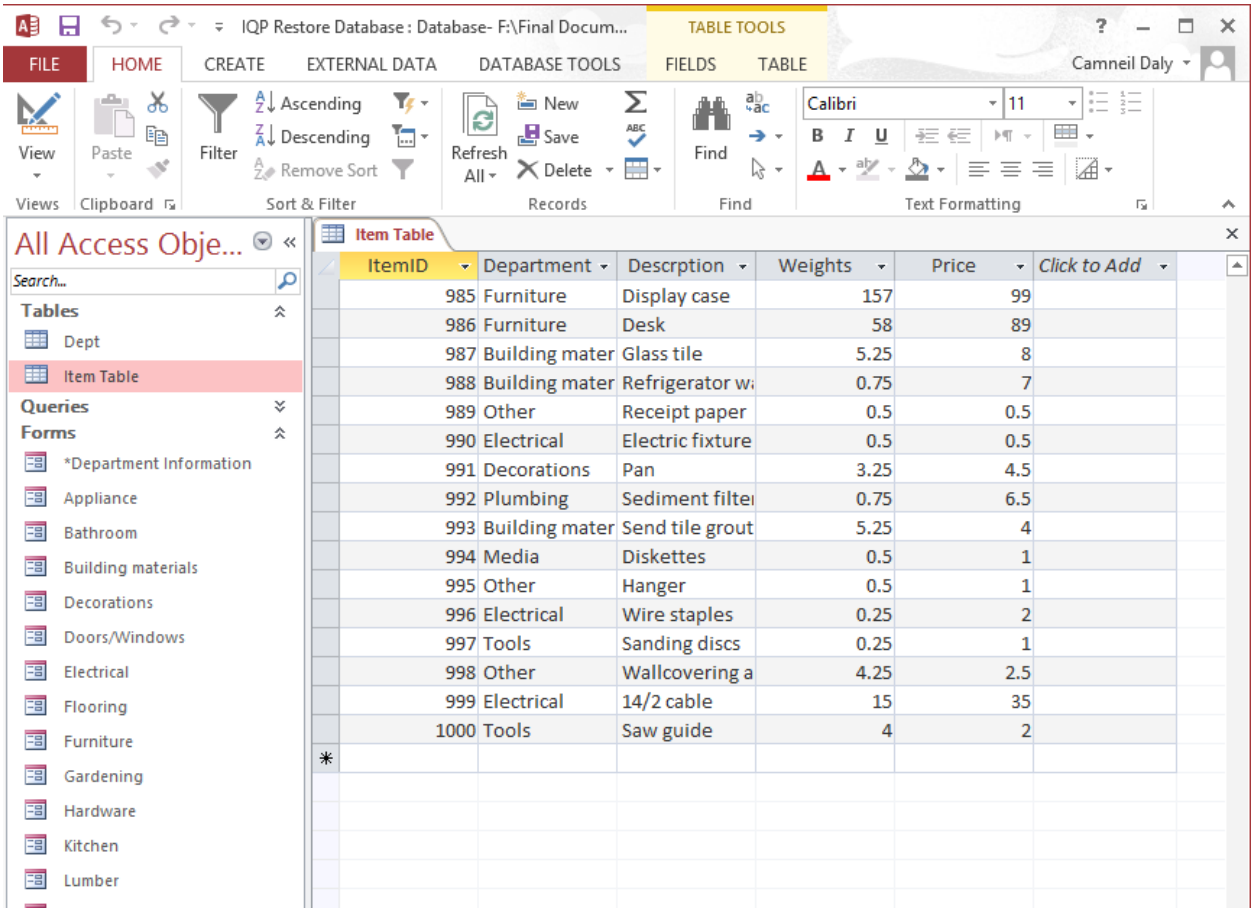

Figure 8: Screenshot of Database

5.2.2 Derive concrete criteria for departments

In order to maximize the accuracy of estimation, it is recommended that the ReStore creates a specific set of criteria for classifying items into departments. Our weight estimation method makes use of the number of items sold and total sales for each department. Lack of communication between the donations-processing attendant and the register invites discrepancy among an item's correct department. At the register, the cashier can change the specified department as needed when he or she enters sales data into the system. However, it is very possible for the employees to differ on which item belongs to which department. As this situation continues, the number of items sold and total sales are likely to experience a larger inaccuracy.

Vague rules for department classification can also cause problems when ReStore updates the database. We have encountered some situations in which it was not clear where to classify an

item just by looking at it. The situation could be solved if some items were classified as they are priced. Employees and experienced volunteers have been great resources for us in this regard. However, if a set of rules for the classification were available, it will not be necessary to request classification or verifications from experienced staff.

Based on our observation and analysis, it is strongly recommended to create a clear list of criteria or guideline for classification of donations. This criteria can be physically placed next to both pricing desk and the cashier's desk or integrated into the current check-out program that they already have. It would be even more efficient if the pricing and cashier's desk can communicate with each other as updates of the criteria becomes necessary.

5.2.3 Improve ReStore's database and check-out systems

To achieve the most efficient method of data collection and analysis, modifying the current ReStore cashier system is necessary. The current system does not allow for the modification of departments. This limits the accuracy of the data. In order to provide a more reliable and accurate tonnage, ReStore needs to revise its current database system. Due to the fact that current system produces the report based on original prices, the ReStore is unable to estimate the tonnage accurately by our conversion factor methodology. Thus, an improved system that considers all sorts of discounts and real sold prices is in need. Also, a system that is able to compare the quantities of items sold weekly and monthly would allow for the comparison of items sold seasonally. An improvement in the ReStore database will alleviate any issues regarding the weight estimation process and the classification of donations sold altogether.

6. Conclusion

After the completion of our project, we have provided an efficient system to estimate weights of donated materials. Through this system, ReStore is able to determine the total tonnage of materials kept out of landfills. This information will assist ReStore in acquiring the grants necessary to improve the overall donations and sales processes. These improvements eventually will encourage more donations and result in higher sales. As result of these positive outcomes, our system will be used by other ReStores in the nation. Moving forward, it is important to note that this is just the beginning of a series of case studies on this topic for the ReStore. Given our time constraints and the database limitations, there is still more work to be done if a more accurate method is to be derived. However, we are looking forward to working with the ReStore and aiding in the acquisition of grants in the future.

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Appendix A: Interview Questions

1. How long have you been working here?
2. What do you do at the ReStore?
3. What are your thoughts on additional steps to the donation process?
4. What is the current method on pricing donations?
5. Is there sufficient manpower currently at the ReStore?
6. Do you have an idea on how to optimize ReStore's current donation process?
7. Which department do you think will be the hardest to estimate tonnage?
8. Have you had any problems with volunteers/employees at the ReStore?

Appendix B: User Manual

Database User's Manual

Habitat for Humanity ReStore

MetroWest/Greater Worcester Area

Created February 2015

Table of Contents

Chapter 1: Weight Estimation

Editor's Note:

In this section, the process of weight estimation is described. There are two methods of weight estimation: one based on average weights by department and one based on monetary value by department. It is important to note that the factors used to derive the weight estimation are based on a sample of donations collected during February of 2015. In order for the factors to be more accurate for this process, the database will need to be updated. The procedure for updating the database is described in Chapter 2 of this manual.

1.1 Average Weight By Department:

This method of weight estimation is dependent on the average weight by department through the database provided with this document. The procedure for determining the tonnage of donations using this method are as follows:

1. In an individual department, locate the quantity of items sold during that month.
2. In an individual department, identify the average weight. It will be provided at the end of this document.
3. Multiply the quantity of items sold and the average weight for the individual department. This product represents the weight estimate for each department.
4. Repeat steps 1-3 for each department in the ReStore monthly report.
5. Add up each of the weight estimates per department. This represents the poundage of donations for that particular month.
6. Divide the weight estimate for the month by two thousand (2000). This now represents the tonnage of donations for that particular month.

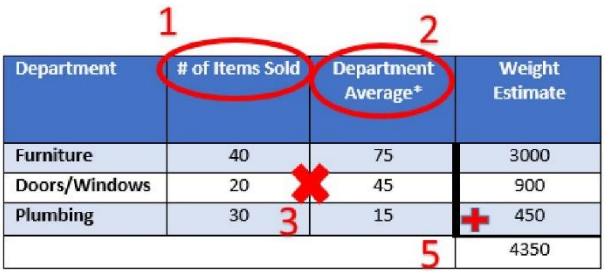

Figure 1-1: Estimation using Average Weight

1.2 Monetary Value By Department:

This method of weight estimation is dependent on the average weight by department and the average sales price by department. The major factor used in this method is the weight conversion factor. It is the ratio of the average weight by department divided by the average price by department. Its units are pounds per dollar [lbs/$]. The procedure for determining the tonnage of donations using this method are as follows:

1. In an individual department, locate the total sales price during that month.
2. In an individual department, identify the weight conversion factor. It will be provided at the end of this document.
3. Multiply the total sales and weight conversion factor for the individual department. This product represents the weight estimate for each department.
4. Repeat steps 1-3 for each department in the ReStore monthly report.
5. Add up each of the weight estimates per department. This represents the poundage of donations for that particular month.
6. Divide the weight estimate for the month by two thousand (2000). This now represents the tonnage of donations for that particular month.

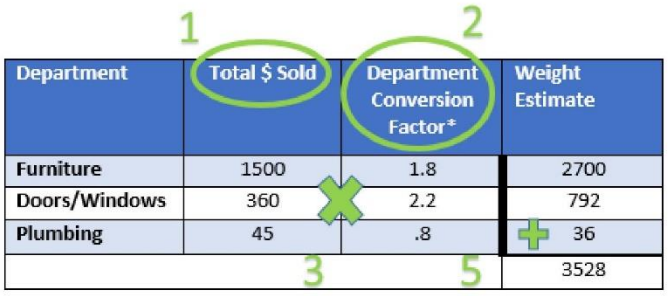

Figure 1-2: Estimation using Conversion Factor

1.3 How to obtain the necessary values from Microsoft Access:

When the "Item Table" is updated and saved, the Microsoft Access database automatically calculates and updates all conversion factors and average weights. A shortcut to pull out all the average weights and conversion factors is to click "Department Information" under the forms section of the Access database (located in the red circle in Figure 1-3). It is then possible to click on the different departments from the list of departments (located in the blue circle in Figure 1-3) and to the right of the list is the average weight, average price, conversion factor and quantity of items in that department (located in the orange circle in Figure 1-3).

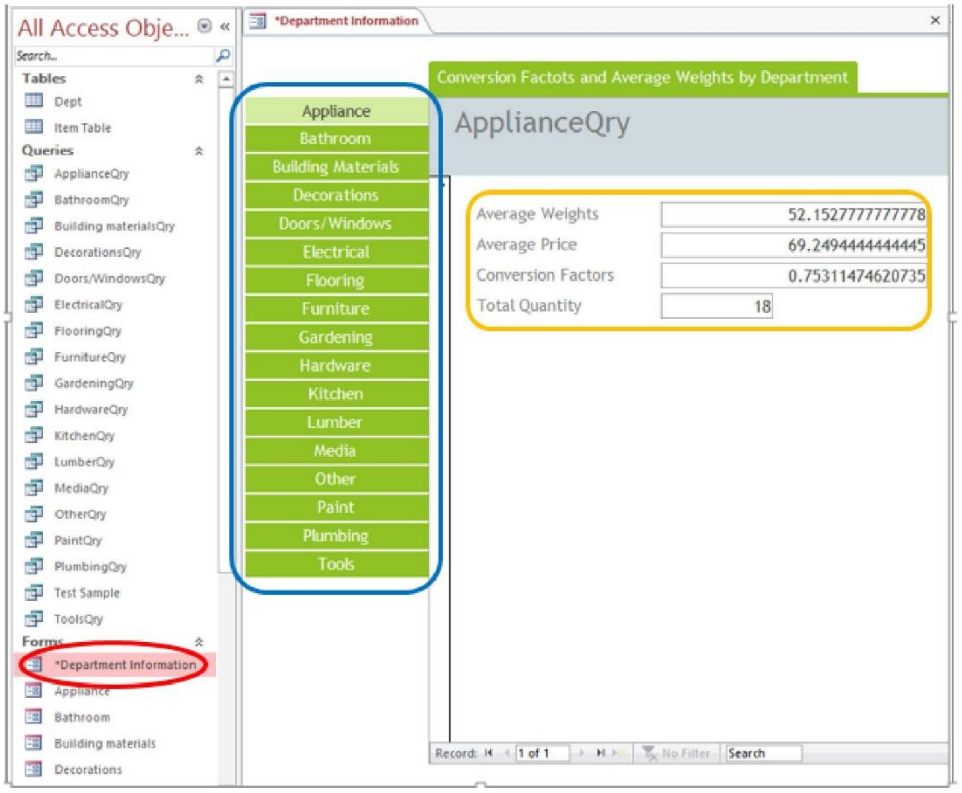

Figure 1-3: Microsoft Access Database Interface

Please note that all "queries" and "forms" created are for the internal calculation use only. Thus, there is no need to click and open any "query" and other "form" tabs in order to avoid the mistakes and keep the integrity of the database.

1.4 How to use values from Microsoft Access to estimate the weights:

In order to use the values to estimate the tonnage of materials, open the excel file titled "Tonnage Estimation Toolbar." In order to find the tonnage using the weights method, insert the average weight for each department from the "*Department Information" form on the "IQP Restore Database" and the number of items sold from the sales report. Once these numbers are inserted for each department, the spreadsheet will calculate the Total Tonnage automatically. In order to find the tonnage using the price method, input the Total Sales Price found in the sales report as well as the conversion factors located in the "*Department Information" form on the "IQP Restore Database." Once these numbers are inserted for each department, the tonnage of materials using the price method will automatically be calculated.

Department	Average Weight (lbs)	Number of items Sold	Total Sales Price ($)	Conversion Factor (lbs/$)	Tonnage Using Weight Method (tons)	Tonnage Using Price Method (tons)
Appliance	1.00	1.00	1.00	1.00	0.0005	0.0005
Bathroom	1.00	1.00	1.00	1.00	0.0005	0.0005
Building materials	1.00	1.00	1.00	1.00	0.0005	0.0005
Decoration	1.00	1.00	1.00	1.00	0.0005	0.0005
Doors/Windows	1.00	1.00	1.00	1.00	0.0005	0.0005
Electrical	1.00	1.00	1.00	1.00	0.0005	0.0005
Flooring	1.00	1.00	1.00	1.00	0.0005	0.0005
Funriture	1.00	1.00	1.00	1.00	0.0005	0.0005
Gardening	1.00	1.00	1.00	1.00	0.0005	0.0005
Hardware	1.00	1.00	1.00	1.00	0.0005	0.0005
Kitchen	1.00	1.00	1.00	1.00	0.0005	0.0005
Lumbers	1.00	1.00	1.00	1.00	0.0005	0.0005
Media	1.00	1.00	1.00	1.00	0.0005	0.0005
Other	1.00	1.00	1.00	1.00	0.0005	0.0005
Paint	1.00	1.00	1.00	1.00	0.0005	0.0005
Plumbing	1.00	1.00	1.00	1.00	0.0005	0.0005
Tools	1.00	1.00	1.00	1.00	0.0005	0.0005
				Total Tonnage (tons)	0.0085	0.0085

Figure 1-4: Tonnage Estimation Toolbar.xlsm

After the users obtain the updated values, it is necessary to open "Tonnage Estimation Toolbar" excel file (as shown in Figure 1-4) to input the values into corresponding fields (columns with red and green colors). The average weights and conversion factors for each department can be obtained from the Microsoft Access file, as explained in previous section, 1.3. The number of sold items and total sales prices are to be obtained from the sales report. After the users update all the attributes in the spreadsheet, the estimated weights for each department are presented automatically at two columns of right end - "Weights Using Weights" and "Weights Using Price". Also, at the very bottom of the last two columns are the total weight estimation using different method.

***Please note that "Number of Items Received" in the excel file, meaning the amount of received donations that users try to estimate weights, does not equal to "Total Quantity", meaning the total quantity of items since the first record, in Access file. Also, the conversion factors and average weights are in auto-decimal format, which is subject to change to other decimals upon users' need.** *

Chapter 2: Database Updates

In this section, the details of data collection and database update are described. The data collection procedures are based on those followed during February 2015 by an Interactive Qualifying Project team from Worcester Polytechnic Institute. This section will also provide a step by step procedure as well as information on how to collect future data.

2.1 How to Collect Data:

When a donation arrives at the ReStore or it is taken from the floor for sampling, the data points that are necessary for a system update are as follows:

1. **Item ID** - The item ID is assigned to *every* item that is weighed in ascending order. When a new data collection process starts, the number should proceed the last number on the existing database.
2. **Department** - The department for an item should be assigned based on how ReStore classifies donations. The items with printed price tags are already classified into a department. With items that do not have the printed price tag or that have not yet priced it is intuitive to define a department for an item. However, it is strongly recommended to be confirmed by employees or experienced volunteers.
3. **Item Description** - The item description is for what purpose?
4. **Item Weight (lb.)** - The weight of items are recorded in pounds.
5. **Item Price ($)** - The item price is determined by employees or skilled volunteers before the item is placed on the floor. It is important to remember to record the prices of items that are weighed before they are priced.

Other columns can be added, if necessary. However, these five attributes are required for the estimation methods described in the previous section. During data collection, data is recorded directly in the original database using Microsoft Access. There are two roles in data collection process: someone to record data and someone to move donations. For an efficient data collection, it is recommended to have at least two people to move around and place the items on the scale floor. Also, a way to mark donations is necessary. Small labeling stickers and a marker is recommended. The use of these marking tools are described below.

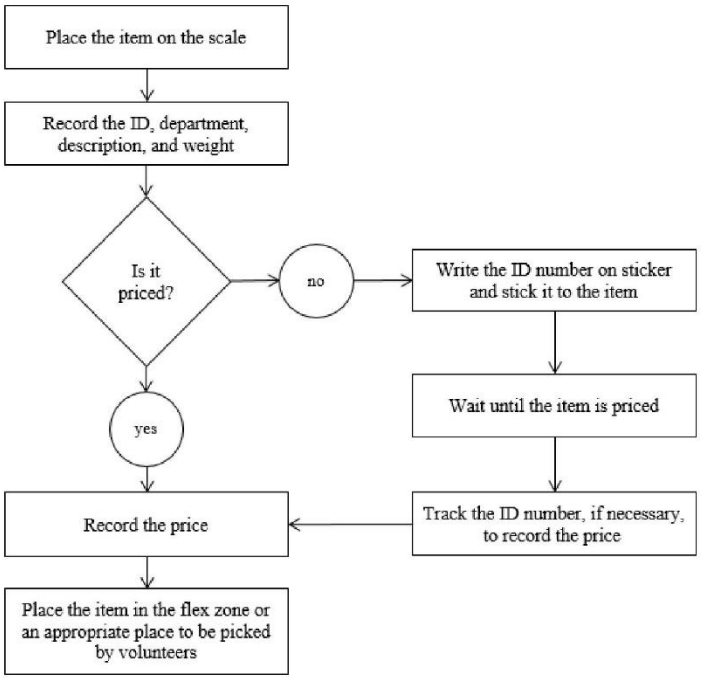

Figure 2-1: Data Collection Procedures

The flow chart of data collection procedures is shown in Figure 2-1. After donated items are unloaded, they need to be weighed before they are placed on the sales floor. The item ID, department, item description, and weight should be recorded as an item is placed on floor scale. If the item is priced already, its price then need to be recorded. After all the attributes for the item is filled in, it can be moved to an appropriate place to be picked up and placed by volunteers. If it is not priced yet, write the item ID on a labeling sticker and place it on the item. This label will be helpful for cases in which there are several items that are weighed but not priced beforehand. Also, when the item is moved to the sales floor without its price recorded on the database, the item can be tracked using this label and other information.

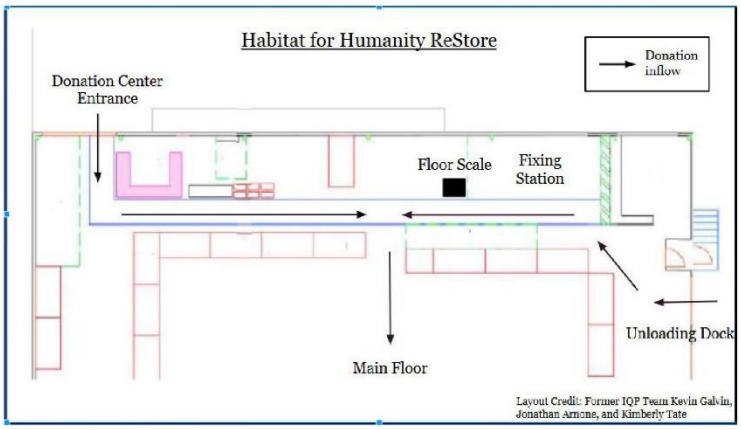

Figure 2-2: Layout of ReStore donation processing area

The location of the floor scale is marked on the layout shown in Figure 2-2. For the 2105 winter IQP team, the floor scale was located right next to the white wooden partition between the flex zone and the fixing station. This location is chosen to be closest possible to the hallway to the sales floor, not being a disturbance for moving donations around. This location can be adjusted as layout of the donation processing area changes, but the location marked on the figure is recommended.

2.2 How to update the database:

When the user opens the Microsoft Access data file, one needs to click the" ItemTable" Tab located under "Tables" under the "All Access Objects" panel of Microsoft Access (shown in the red circle in Figure 2-3) where the user could input more data points. After typing all the latest data, it is necessary to close the table using the "x" shown in the green circle of upper right in Figure 2-3 and then save the database. This will allow the database to update automatically. When the user finishes the usage of Access, it is important to click "Compact and Repair Database" under Database Tools (located in the blue circle of upper left in Figure 2-3) to maintain the integrity of the database.

One needs to assign and record the Item ID of the item, the department the item falls in, a description of the item, the weight of the item and the price of the item at the bottom of the database (represented in the purple circle win Figure 2-3).

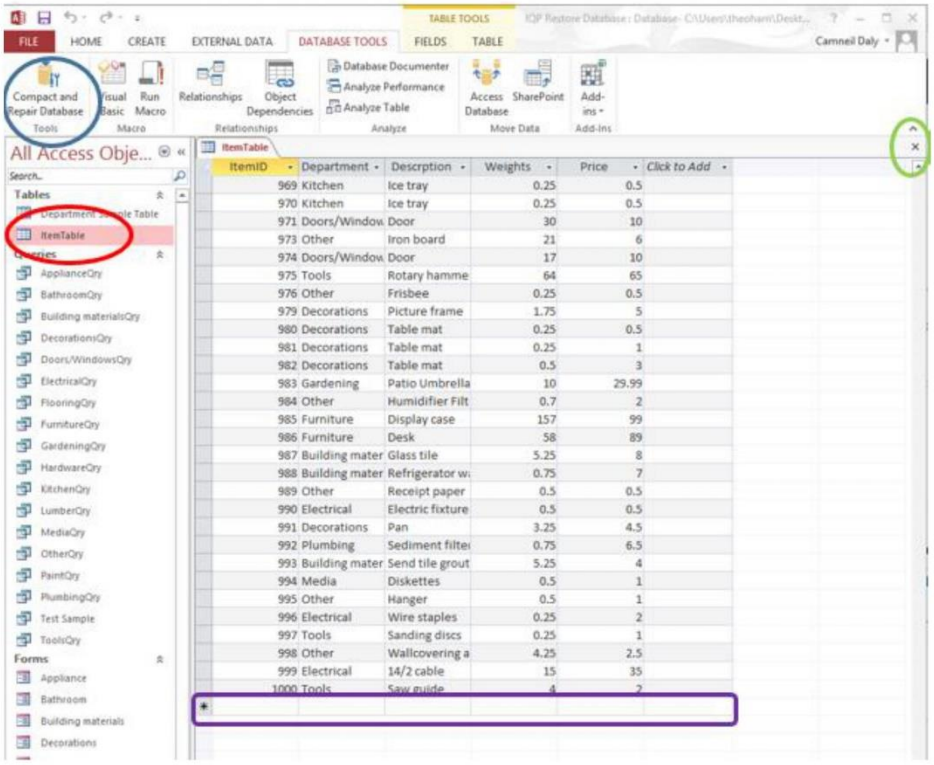

Figure 2-3: Screenshot of Database

Chapter 3: Troubleshooting

Possible Problems

There are plenty of issues that could arise from the following chapters. In this chapter we will address some possible problems and how to solve them efficiently. The most common ones are:

1. Keeping up with donations processing
2. Collecting data in an efficient manner
3. Lack of data
4. Microsoft Access not updating

3.1 Keeping up with Donations Processing

During the busier months at the ReStore, it is possible that data collection will be a challenge due to the amount of donations arriving each day. Also, once donations have arrived, it is possible that there will not be room in the ReStore for data collection. There is a limited amount of space in which donations may be processed and there might not be room for a scale.

Therefore, in order to keep up with the donations process, an open line of communication must be created with the staff pricing the donations that day. At the beginning of the day, it needs to be expressed that those collecting data are there to collect data only. It also needs to be expressed that pricing donations needs to be swift. Without pricing at a rapid pace, there is a chance that the donations processing area could overflow, limiting data collection. Once items are priced and weighed, they can be moved to the floor. This line of communication will limit the amount of donation overflow as well as the efficiency of data collection.

3.2 Collecting Data in an Efficient Manner

In order to collect data in an efficient manner, there are two things to be taken into consideration. One is that the team must be keeping up with donations processing. The other is balancing the collection of data and moving around donations in the donations processing area. When there are numerous donations awaiting data collection, it is important to collect data in a systematic manner. Items that are more easily moved and closer to the scale in general should be utilized for data collection first. After, the heavier, more bulky items should be used. Also, it is recommended that as donations are moved to the sales floor, the donations awaiting data collection be consolidated into a more compact area. This limits clutter and creates a cleaner work environment.

When actually collecting data, it is recommended that it is done in a team of three. By having someone with access to the database right next to the scale at all times and two others moving donations off and on the scale, data is collected at a faster rate. Also, when those who are moving items on and off the scale read off important data sets from a donation, the person with access to the database only has to focus on recording rather than reading off data. In terms of moving around donations, volunteers should be the only ones bringing donations to the sales floor. Otherwise data from certain donations could be missed.

3.3 Lack of Data

During the months of the year that are not as busy, there could be a lack of data that is collected from the influx of donations. Therefore, it is necessary to collect data from items already on the sales floor. Since there will not be a large influx of donations at this time, there is time for those in charge of moving donations to and from the scale to go out onto the sales floor and select items for data collection.

3.4 Microsoft Access Not Updating

If new data is imputed into the "ItemTable" and the average weights, average prices, conversion factors and quantity for each department are not updating automatically, there are a number of steps to fix this problem:

1. Make sure that all tabs are closed and that you save the database. Reopen the "Department Information" tab and check to see if the numbers have changed.
2. If step 1 doesn't work, close all tabs and check one department tab under the "Queries" section (each query should say the department name followed by the letters "Qry" ex. FurnitureQry) to make sure the queries are functioning properly. In order to do this follow these steps per department and repeat for all departments that won't automatically update:
    a. Click on one of the queries for a department
    b. Under "Home" click on the arrow under "View" on the left of the screen.
    c. Click on SQL view. This should change the table and you will see text appear on your screen.
    d. Make sure that the text reads:

```
SELECT Avg([Weights]) AS [Average Weights], Avg([Price]) AS [Average Price], Avg([Weights])/Avg([Price]) AS [Conversion Factors], count(*) AS [Total Quantity]

FROM Itemtable

WHERE (((Itemtable.[Department])="Appliance"));
```

    If it doesn't read this exactly, delete the current text and copy this text onto the screen where the text once was

    e. After this click "Run" (located right next to "View")
    f. Close all tabs currently open and save Access
    g. Go to the "Department Information" form under Forms to see if the database updates