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To: Professor Katie Fitzsimons

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Subject: Initial Research for the Design of a Wheelchair-Operated Food Dispenser for Canine Training

Introduction

Data from the 1994 National Health Interview Survey Disability Supplement indicates that between 1980 and 1994, an 83% increase occurred in reliance on mobility equipment such as wheelchairs [1]. The increasing reliance on wheelchairs requires additional care that may be too difficult for people in wheelchairs to perform themselves, decreasing their independence in competing daily tasks. Many of these people use service dogs to assist with these daily tasks, but service dogs can be expensive and difficult to train. Canine Companions for Independence (CCI) is a nonprofit organization dedicated to providing service dogs at no cost for people with a wide range of disabilities to help people complete daily tasks [2]. Although these service dogs go through strict training before being assigned a client, they often require lifelong training according to their client's specific needs [3].

Partnering with Canine Companions for Independence, a junior-level design course (ME 340) in the Department of Mechanical Engineering at Penn State has tasked our team to design a wheelchair-mounted kibble dispenser to help the people that CCI services. Our customers are people with low dexterity who are in wheelchairs, because they struggle the most to interact with their service dogs. In this report, low dexterity focuses on small-scale dexterity, where people struggle with fine-muscle movements such as moving fingers [4].

This report presents the initial research into customer needs as well as metrics and specifications for a wheelchair-operated dog food dispenser. The customer needs are outlined-in the next section. Presented in the third section are the benchmark specifications that our design must meet. Additionally, in that third section, we will discuss how we plan to test each specification. In the conclusion section, we present our project management plan to go forward with the rest of the project.

Customer Needs for Design Project

To design a wheelchair-operated food dispenser, our team first identified customer needs. These needs are based on interviews with clients [5], information from CCI's website [2], and requirements given by the project description [5]. Using the information provided, our team grouped customer needs into primary needs and secondary needs. Our team identified the primary

needs to be that our dispenser is easy to use and have a controlled release. For the dispenser to be easy to use, our team identified two secondary needs—namely, that the dispenser is portable and durable. Other needs of lesser importance identified for the dispenser design were the food safety of the dog food dispensed and the ability to store kibble before being dispensed.

Our first primary need is that the dispenser is easy to use with secondary needs of being portable and durable. The primary needs of our design must align with the needs of our model customer. It is important for people in wheelchairs who lack mobility that our product is easy to use in order to perform successful training of service dogs. The abnormal S-shaped kibble used in this project presents a problem for our low dexterity customer who might struggle with such fine hand movements such as picking treats out of a bag [6]. To ensure the product's ease of use for those with limited mobility, the dispenser needs to be both portable and durable. Having access to a portable dog food dispenser can allow a person in a wheelchair to train a service dog anywhere, increasing their independence. A more durable dispenser increases the lifetime of the product and allows it to withstand higher impact forces during training. Increasing these factors increases the reliability of the product and allows for more service training.

A second primary need is that the device has a controlled release of kibble to instill proper behavior during service dog training. Our team defined control as the dispenser's ability to ensure the kibble never touches the ground and to dispense only one treat at a time. According to an article written by the International Association of Animal Behavior Consultants [7], training service dogs necessitates that the food stays off the ground at all costs to maintain discipline in the dogs. Taking the proper steps to ensure the kibble stays off the ground can prevent bad behavior from forming in the dog. Additionally, the control of the kibble release is important because too much reward can lead to a dependency on food for the dogs to do tasks [7]. If the dispenser outputs a variable amount of kibble, the service dog may form behavioral problems.

Additionally, the dispenser needs to be able to store food and be able to dispense it in a food-safe manner. The dispenser needs to be able to store food before dispensing to limit fine hand movements and the food needs to be safe for the service dogs to eat. According to FDA regulations [8], the device needs to be clean, dry, and covered with a lid to keep the food fresh and prevent the service dogs from accessing the food. This lid needs to be accessible and easy to open without hand dexterity. The storage of the kibble needs to be safe for the product to be effective. The dispenser needs to be able to provide the customers with what they need to receive the full care they deserve.

Accompanying Metrics and Specifications

After establishing our customer needs for the kibble dispenser, our team developed a set of metrics and specifications for each need. To track these needs, metrics, and target values, we created a quality function deployment (QFD) chart, which can be found in Table 1. A QFD chart allows us to chart the most important needs of the customer in the rows, and the associated metrics and specifications in the columns. At the bottom of the chart are the specifications identified for each metric. This section describes how each metric relates to each of our high-importance needs, as well

as presents associated target specifications and details on how we plan to test each metric according to those specifications.

Table 1. QFD table with customer needs and accompanying metrics and specifications for wheelchair-operated food dispenser.

		Metrics					
		Weight of Dispenser	Volume	Amounts of treats dispensed	Time to dispense	Force for operation	Impact Force Height without damage
Needs	*Easy to use*	●	●		●	●	
	- Portable	●	●				
	- Durable						●
	Controlled Release			●			
	Minimum	N/A	N/A	1 treat	N/A	N/A	3 ft
	Maximum	5 lbs	0.88 cubic ft.	1 treat	5 seconds	5 lbs	4 ft
		Target Values					

The first primary need for our product is for the dispenser to be easy to use. For the dispenser to be easy to use, it also needs to be portable and durable. A specific metric for ease of use that we will use is time to dispense and force of operation. For time to use, our target specification is 5 seconds. This time comes from a patent for a similar product: a stationary treat dispenser for dogs [9]. Because this patent detailed that the total time to dispense the treats to the pets would be 5 seconds, we will use the same target value. We will test this target with multiple timed trials, and if the average time to dispense is less than 5 seconds, the metric will be met.

Another metric for ease of use is the force needed to operate the kibble dispenser. As outlined in the ADA standards, any operable parts must be controlled through a force of no more than 5 pounds [10]. Therefore, we set our target value for this metric to be a maximum of 5 pounds to dispense a treat. We will test this metric by applying 5 pounds onto the operable part of the dispenser. If a treat dispenses, we will consider this metric to be met.

The first secondary need for the dispenser to be easy to use is for it to be portable. We chose the weight and volume of the dispenser to measure how portable it is. For the weight of the dispenser, it should not be heavier than 5 pounds. This metric was developed from the ADA government design standards, which detail that anything operable must be able to be operated by a maximum of 5 pounds [10]. We will measure and test this metric using a simple scale. The total volume of the dispenser should also be able to fit in a common backpack. This size restriction will allow the dispenser to be transported easily and will make mounting to a wheelchair easier. Since the standard size of a backpack is about 0.88 cubic feet [11], we chose our target specification for the volume metric to be a maximum of 0.88 cubic feet. We will test this metric throughout our

development process, because most design software has a tool to test and measure the volume of the entire part. If the volume is under 0.88 cubic feet, then we will consider the dispenser to meet the metric and target specification.

The second secondary need for the product to be easy to use is for the dispenser to be durable. The accompanying metric we chose for this need was the height at which dispenser can withstand a drop without any significant damage occurring. We developed the accompanying target specification to be a minimum of 3 feet, and a maximum of 4 feet, which is from the ASTM F96323 standard pertaining to consumer toy safety [12]. Significant damage in this case means any damage that will either hamper or stop the operating of the dispenser or dispensing of the kibble. We will test this metric through drop tests. We will operate the dispenser to make sure it is working, and then drop the dispenser from 3 feet off the ground and verify that it is working. If it is working, then the minimum target value for that metric has been met.

The final primary need is the controlled release of the kibble. For this metric, our target value is a minimum and maximum of one treat. We chose this target value due to background information that the customer provided [5]. To test this metric and the associated target values, we will simply operate the device at least twenty times and cause the kibble to dispense from the machine. If there is one kibble dispensed each time, then the test is successful. If there is no kibble or more than one kibble dispensed per operation of the machine, then we will not meet the metric and target specification.

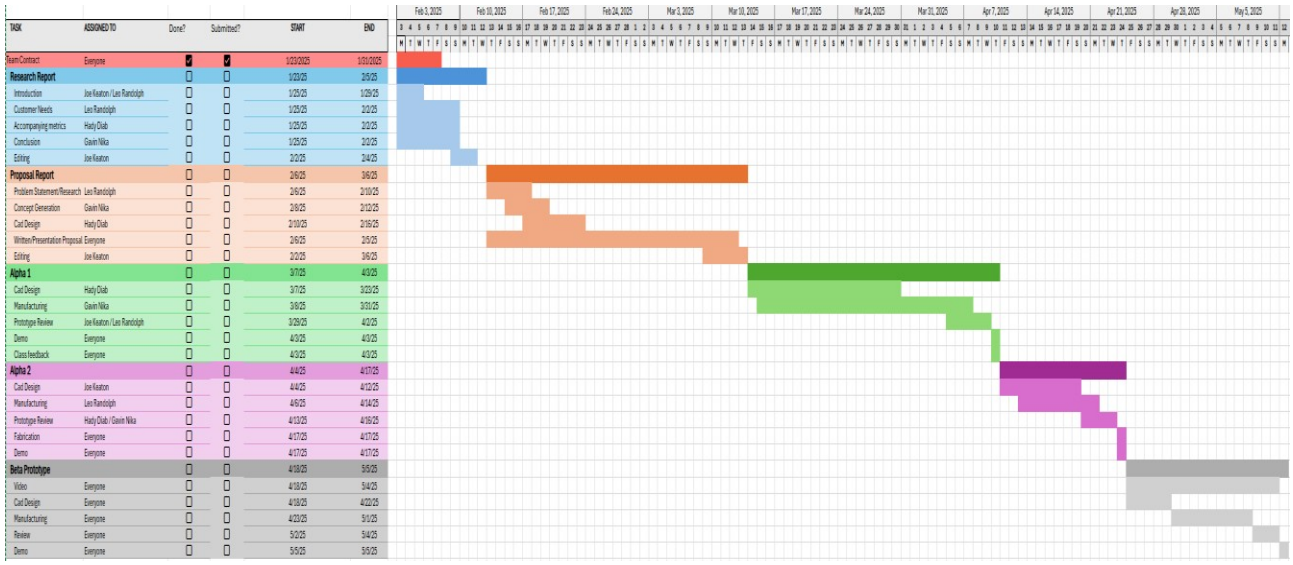
Conclusion

Canine Companions for Independence has tasked our junior-level design course with designing a dog kibble dispenser that is to be operated by individuals with low dexterity. This report has presented the customers needs for a kibble dispenser—namely, that it is easy to use, portable, durable, and has a controlled release. The purpose of this report is to explore the development of a product that suits the needs of low-dexterity individuals and their service animals. Recognizing needs and creating specifications is only the first step in product development. Our team will use the defined needs and metrics found in the report as we progress in the design process.

Tasks such as designing, manufacturing, and testing are the bulk of product development. A management plan, as seen in Appendix A, has been created to streamline these tasks. Now that we have researched the problem, we are ready to design a solution that meets the needs of the customers.

Appendix A: Management Plan

Every successful team has a good management plan. Management plans require schedules with deadlines. We made this schedule by breaking down the project into tasks and constructing a Gantt chart, as shown in Figure A-1. These tasks have been broken down into research report, proposal report, alpha 1 prototype, alpha 2 prototype, and beta prototype. The purpose of the Gantt chart is to provide a visual aid to better understand the team's progress. The Gantt chart also provides deadlines for all the tasks. Deadlines aid in timely and efficient work.



TASK	ASSIGNED TO	Done?	Submitted?	START	END
Team Contract	Everyone	☑	☑	1/23/2025	1/31/2025
Research Report		☐	☐	1/23/25	2/6/25
Introduction	Joe Keaton / Leo Randolph	☐	☐	1/25/25	1/29/25
Customer Needs	Leo Randolph	☐	☐	1/25/25	2/2/25
Accompanying metrics	Hady Diab	☐	☐	1/25/25	2/2/25
Conclusion	Gavin Nika	☐	☐	1/25/25	2/2/25
Editing	Joe Keaton	☐	☐	2/2/25	2/4/25
Proposal Report		☐	☐	2/6/25	3/6/25
Problem Statement/Research	Leo Randolph	☐	☐	2/6/25	2/10/25
Concept Generation	Gavin Nika	☐	☐	2/6/25	2/12/25
Cad Design	Hady Diab	☐	☐	2/10/25	2/19/25
Written/Presentation Proposal	Everyone	☐	☐	2/6/25	2/6/25
Editing	Joe Keaton	☐	☐	2/2/25	3/6/25
Alpha 1		☐	☐	3/7/25	4/3/25
Cad Design	Hady Diab	☐	☐	3/7/25	3/20/25
Manufacturing	Gavin Nika	☐	☐	3/8/25	3/31/25
Prototype Review	Joe Keaton / Leo Randolph	☐	☐	3/28/25	4/2/25
Demo	Everyone	☐	☐	4/3/25	4/3/25
Class feedback	Everyone	☐	☐	4/3/25	4/3/25
Alpha 2		☐	☐	4/4/25	4/17/25
Cad Design	Joe Keaton	☐	☐	4/4/25	4/12/25
Manufacturing	Leo Randolph	☐	☐	4/6/25	4/14/25
Prototype Review	Hady Diab / Gavin Nika	☐	☐	4/13/25	4/16/25
Fabrication	Everyone	☐	☐	4/17/25	4/17/25
Demo	Everyone	☐	☐	4/17/25	4/17/25
Beta Prototype		☐	☐	4/18/25	5/5/25
Video	Everyone	☐	☐	4/18/25	5/4/25
Cad Design	Everyone	☐	☐	4/18/25	4/20/25
Manufacturing	Everyone	☐	☐	4/23/25	5/1/25
Review	Everyone	☐	☐	5/2/25	5/4/25
Demo	Everyone	☐	☐	5/5/25	5/5/25

Figure A-1. Gantt chart showing the remaining assignments for the rest of the semester. The Gantt chart includes the project tasks, the team member(s) in charge of each task, and the dates and duration of each task. The different colors correspond to different main segments of the process. Blue is the research report, Orange is the proposal report, green is the alpha 1 prototype, pink is the alpha 2 prototype, and grey is the beta prototype

Each subtask of the Gantt chart has been decided based on everyone's prior experience and abilities. It should be noted that the workload will be shared, but someone will guide the work based on their experience. Hady has the most experience with CAD software, so he will take the lead on the design portion. Because Joe is a solid writer and has taken several writing courses, he will be the lead editor to make sure everything looks polished. Leo is the project manager because he has experience in all areas and can gauge progress and process quality. Gavin is the manufacturing lead because he has experience in the manufacturing industry.

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