Design of an Automated Cocktail Mixing Experience

by

Alejandro Aguirre

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ABSTRACT

This thesis describes the design concept development of an automated cocktail mixing device and user interface that is capable of dispensing a variety of alcoholic and non-alcoholic ingredients to produce a myriad of drink recipes. The design consists of twelve containers, each connected to an electronically controlled valve, mounted over a circularly symmetric frame that houses a cup while ingredients are dispensed into it.

A user study was conducted in which participants responded to questions regarding their drinking habits, drink preferences and perceived experience/knowledge of mixing cocktails. In addition, participants were asked to rate a variety of functionalities that might be found in an automated cocktail mixing device based on how important or crucial they perceived them to be. The responses collected through this user study were used to drive the direction of the design concept development.

The automated cocktail mixing device design concept was modeled using CAD software in order to better understand the spatial constraints and requirements of the assembly components. This model, combined with the user study and proposed user interface functionalities, serve as the foundation for the further development of the product.

Thesis Supervisor: David R. Wallace
Title: Professor of Mechanical Engineering

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Introduction

1.1 Idea

With the rapid growth of DIY culture has come the automation of various tasks that we are faced with in our daily lives. One of the latest and most interesting themes in the DIY arena that will soon begin to draw attention in the commercial marketplace is that of automating the mixing of cocktails.

Because this theme of products has not been in existence for a long period of time, the automated cocktail mixing devices have really only appeared in the form of personal projects by hobbyists and hackers. The basic functionalities of these existing prototypes do seem to meet the standard definition of what an automated cocktail mixing device should be, but many are not designed with the end-user in mind. Many of the designs required the use of expensive parts, lacked any versatility in its drink-making ability, performed unnecessary tasks or simply took too much time to process a drink order. In order to move this category of products closer to a position in the commercial market, a device would need to be designed around the customer's needs and produce an intuitive and versatile user experience.

The design concept in its original form was a series of containers, mounted over a platform, in which the user would pour the desired ingredients. Using a digital interface, the user would set each container to its respective ingredient, then select a recipe from the dynamically generated list of available drinks or create a custom recipe and save it for later use. Figure 1 shows the initial sketch drawn for the mechanism concept that was pursued at the onset of the design concept development process.

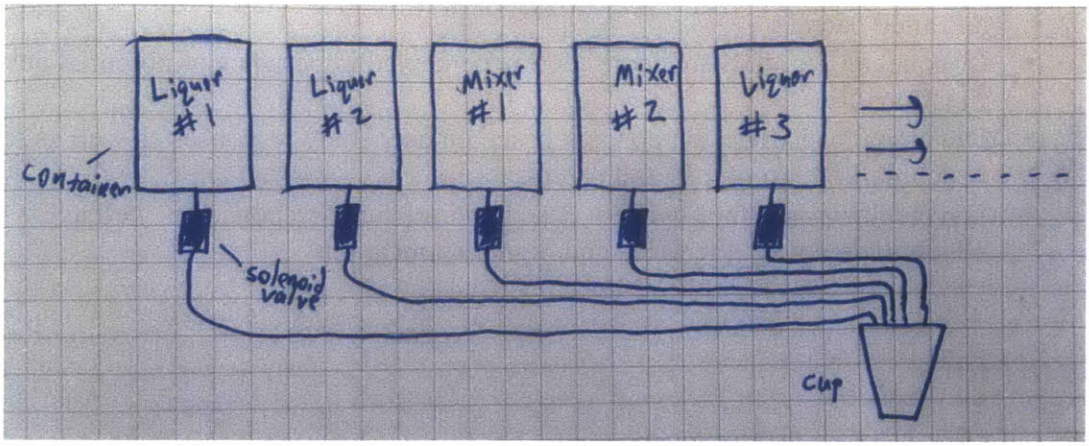


Figure 1: Initial sketch of design concept that was further developed

1.2 Need

A product such an automated cocktail mixing device has numerous potential uses, in both personal and business settings. Going out to bar can be quite costly for the average individual, but gaining access to a lively social scene and a bartender who has extensive knowledge of drink

recipes is often worth the price that is paid. With the increasing prices of drinks at bars and decreasing prices of spirits at stores, however, it seems to be much more economical to purchase your own liquor and host a private party in your own home. The missing factor in this scenario would still be the easy access to a vast knowledgebase of cocktail recipes and convenience of placing a drink order then having it made for you, which is where the automated cocktail mixing device plays a key role. (For more information on the pricing standards of alcohol in bars and in stores, see section 2.1)

In addition to personal in-home use, this product has the potential to completely change the way the common beverage service business is run, specifically through bars and caterers. Many different automation technologies have made human operators obsolete through the development of technology, but one that has yet to be pushed aside by technology is the bartender. By integrating this product into bars or catering companies, business owners can provide their patrons with an intuitive and entertaining user experience that will produce their drink order faster and possibly more accurate than a bartender could. With these different end-use possibilities, it's clear to see that there is a potential need for this product both in your home and in the future of the beverage service industry.

1.3 Thesis Goals

At the onset of this project, I defined a set of goals that would allow me to remain aligned to a focus of investigating what qualities and functionalities of an automated cocktail mixing device would best meet customer needs an provide an optimal user experience. The goals were as follows:

- Investigate the functional qualities of prototyped devices, relevant user interfaces and filed patents
- Conduct a user study to clearly define perceived importance of potential device functionalities
- Develop physical design concept based on user study responses as well as benchmarked prototypes and patents
- Develop user interface concept based on user study responses as well as benchmarked user interfaces and digital applications

1.4 Summary

Throughout the course of this project, the idea for an automated cocktail mixing device illustrated earlier was developed using a detailed assessment of various physical design and digital application design considerations in order to optimize the resulting user experience.

The physical design concept consists of a series of 12 custom-shaped plastic containers arranged in a circular pattern mounted over a support platform that elevates the entire assembly over a space for the placement of a cup. Each of these containers will be fitted with a downward pointing custom nozzle that is normally closed, but when it is interlocked with the valve

enclosure (black box) becomes open to allow flow. This flow is still restricted by the solenoid valve inside the valve enclosure, which will only allow flow when the ingredient in that container is needed.

The user interface concept consists of a digital application that is linked to the control of the solenoid valves in the physical system. With the designed UI functionalities, users will be able to load and register specific ingredients into the liquid source containers, allowing the system to perform dynamic filtering to produce the recipes in its extensive database that could be made with the available ingredients. In addition, users will be able to use the drink database to either input every ingredient available to them and output all available recipes or input the desired drink recipes and output the ingredients required to make them.

Figure 2: CAD model of physical design concept and example cocktail recipe screen

With a clear direction for further product development, the next step will be to develop prototypes that answer the critical questions about this design that must be addressed. Future work on this product should focus on building prototypes to investigate and test the reliability of an interlocking nozzle interface as well as user testing with a working digital application and representative model of the physical device to gain a practical understanding of the user experience resulting from the design decisions made.

Background

2.1 Modern Drinking Culture

When an individual wants to spend time and have drinks with friends he or she typically has only two options. These options are to either go out to a bar and buy individual drinks at marked up prices or purchase ingredients at a liquor store and attempt to mimic the high-quality cocktail mixing skills of a bartender in your own home.

There are many advantages in going out to a bar instead of making drinks for yourself and your friends in the comfort of your own home. One of the primary reasons individuals go to bars is to be exposed to the fun and energetic environment that is common in those kinds of establishments. In addition, patrons will have access to a myriad of menu cocktails that can be ordered by simply requesting them from the bartender. Good bartenders will be able to create most, if not all, popular off-menu drinks simply from memory. Great bartenders will be able to produce a cocktail based on the taste a patron would like their drink to have, such as tangy, minty, sweet or bitter. Bartenders are an amazing resource for those patrons that know little or nothing about cocktails, but the service and convenience they provide can be quite costly.

Just as with going out to bars, there are a number of advantages in simply purchasing liquor from the store and hosting friends in your own home for evening drinks. By purchasing ingredients for drink recipes from a liquor store, individuals can see big savings when comparing their expenses at bars. A secondary benefit to keeping a home bar is the ability to host family, friends and co-workers for a night of drinking in a much more private and intimate environment, which is often preferable over the bustle of a busy bar. The difficulty in home bar, however, is the lack of recipe knowledge and the added inconvenience of having to carefully pour each drink yourself.

A report published in 2012 by NPR showed that the drinking habits of the average American consumer have not changed much in the past 30 years; alcohol represented about 1% of all expenses. What has changed is *where* that money is spent. Figure 1 shows graphically the portion of alcohol spending experienced at both bars and liquor stores in 1982 and 2011. [1]

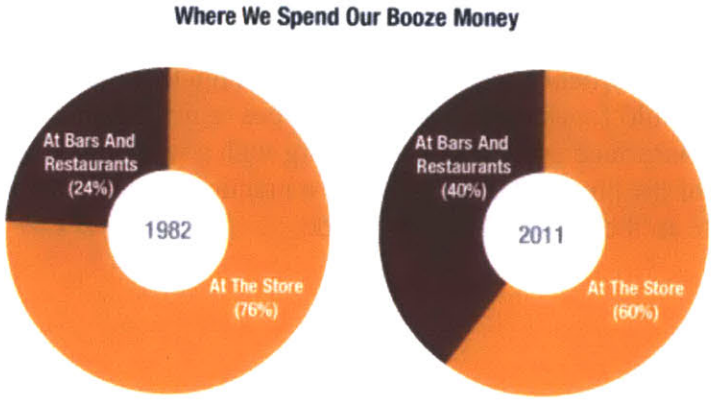


Figure 3: Graphical comparison of alcohol expense streams between years [1]

At first glance, this graphic published by NPR appears to illustrate the growth in popularity of bars and the decline of liquor store purchases, but what it is actually communicating is the increase in market share that businesses that serve alcoholic beverages have obtained over the last few decades due to a steep rise in prices. Between 1982 and 2011, the cost of liquor at bars and restaurants has gone up 79% while the cost of liquor at stores had fallen 39%, adjusting for inflation. This is largely due to the stagnant nature of the alcohol service industry; there have been no major advances in productivity with regards to making and serving drinks, resulting in much higher priced drinks.

Given the rise in alcohol prices in bar settings, it is no wonder that more and more Americans are making the switch to drinking at home instead of going out. This rising trend presents ample opportunity to enhance the in-home drinking experience to more closely match the positive attributes of a bar, such as the convenience of a vast cocktail recipe knowledgebase and ease of producing high-quality cocktails. In order to apply the positive attributes that a bartender brings to the bar-going experience, I decided to position myself to learn the skills and methodologies of a bartender through first-hand experience.

2.2 Drink Master Bartending School

In working towards automating any process, the designer must have some experience and a clear understanding of the manual process to better apply automation technology to that specific application. I would not try to automate the baking of a cake without first knowing what steps are required to be successful, so I would not try to develop a design concept for an automated cocktail mixing device without first knowing what steps are required to produce a high-quality drink.

The introductory course I took part in was conducted by the Drink Master Bartending School and consisted of 20 hours of training in their Downtown Boston teaching bar. The large bar was stocked with bottles of every variety of liquor that are commonly found in the types of establishments I was being trained to work in, along with a standard arrangement of non-alcoholic ingredients around the bar sink and a flexible hose dispenser for carbonated ingredients. The curriculum of the course including learning the basic qualities of different beer and wine types, but the main focus of the course was learning the different classes of liquors, cocktail types and methodologies for portioning ingredients in any recipe.

This course introduced a systematic method of pouring cocktails based on the number of different liquors in the drink, the type of non-alcoholic ingredients in the drink and the relative alcohol content of the different liquors in the drink. Each of these different parameters played a role in determining exactly how much of each ingredient should be added to the drink. This, combined with extensive practice in pouring consistent known volumes, resulted in high-quality cocktails poured in precise proportions. By experiencing this systematic approach to mixing cocktails, it became clear that applying these "rules" to a database of ingredients and recipes and a flexible user interface would allow the user to apply a bartender's expertise to his or her own home bar experience. Table 1 shows some of the "rules" that are applied in practice. Overall, the

experience gained by taking this course has allowed me to apply the basic practices of a bartender to the development of the automated cocktail mixing device concept.

Table 1: Systematic Ingredient Portioning for Different Drink Types

Drink Type	Liquors	Pour Count (1 count = ¼ oz.)	Add Mix?
Highball Glass	**3 Liquors**	**2/2/2 count**	**Yes**
	2 Liquors	3/3 count	
	1 Liquor	4 count	
Rocks Glass	3 Liquors	3/3/3 count	No
	2 Liquors	6/3 count	
Multi-Liquor Glass	5 Liquors	2/2/2/2/2 count	Yes
	4 Liquors	2/2/2/2 count	

2.3 Patents

The original focus of the patent search was to find different types of automatic cocktail dispensers that have been invented. I searched specifically for devices that were designed for the purpose of dispensing alcoholic beverages instead of a general search for devices that dispensed any kind of beverage because I wanted to investigate how past inventors have addressed specific issues relating to the customer needs for an automated cocktail mixing device. Among the results of this search were three different approaches to the automated cocktail mixing device concept, each of which is depicted in Figure 4.

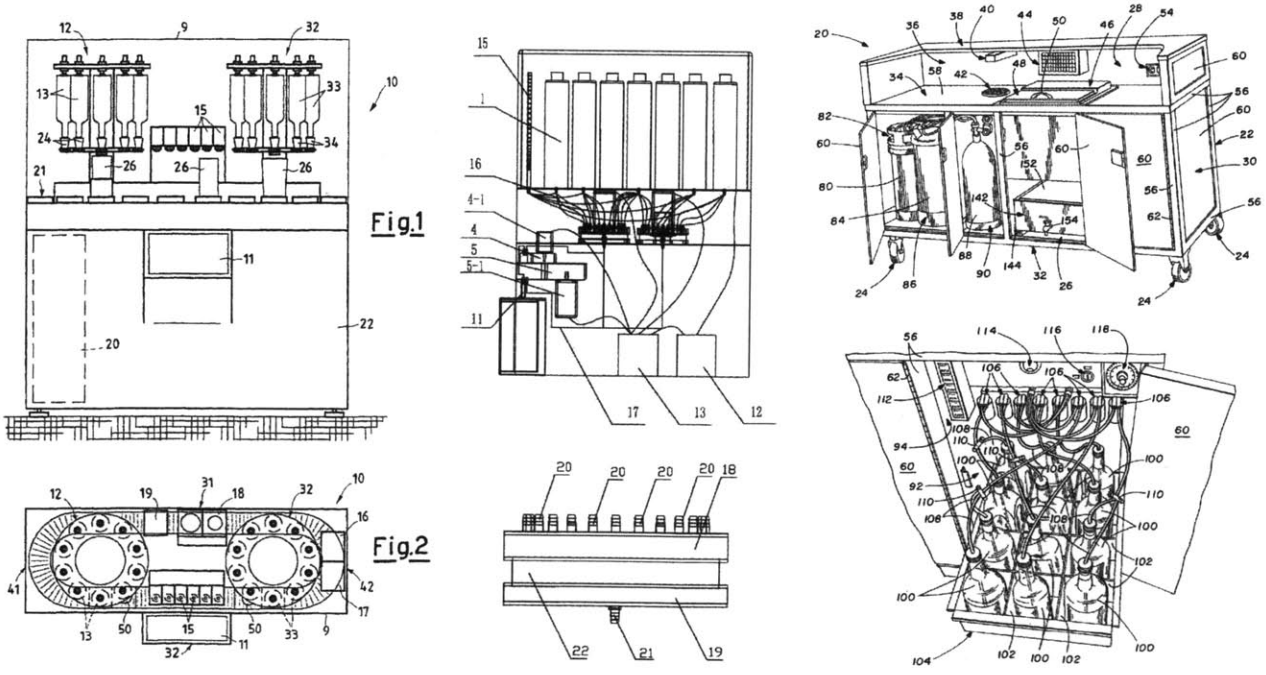


Figure 4: Images from patents for automatic mixed drink dispensing apparatus'. From Left to Right, the images show patents of (1) gravity feed system with integrated conveyor belt [12], (2) a

table top device with manifold for liquid inlet/outlet [13], and (3) a mobile full bar setup with pump system drawing directly from stored bottles [14]

Patent 1 consists of two sets of rotating upside-down mounted bottle fixtures filled with alcoholic and non-alcoholic ingredients as well as a series of smaller containers for topper ingredients, which dispensed using a gravity feed system with magnetic actuator controlling the flow of liquid. The design also includes a conveyor belt that would guide a cup through the system between the alcoholic, non-alcoholic and topper ingredient stations until the drink had been completed. The user is meant to stand at one side of the device, place a cup on the conveyor belt, select a drink order and wait for the cup to approach each of the ingredient stations until it has finally circled through the device and returned to its original position. This design seems to be flawed in that it would take a significant amount of time to process a single order in addition to occupying a much larger amount of space than should be required for such a system.

Patent 2 consists of a compact design with a series of individual ingredient containers connected to a multi-switching inlet/outlet manifold device driven by a servo-motor that is in turn connected to a pump system. The switching device determines from which of the ingredient containers the pump will draw from. This design is very clever in that it minimizes the number of pumps that must be used to draw from any number of ingredient containers to one by simply implementing a secondary actuation device that toggles the flow path between the connected containers.

Patent 3 consists of a mobile full bar setup with an integrated pump system that draws ingredients from their original bottles, which are stored inside one of its cabinets. This design uses much more space than should be comfortable for this type of product, but because the automated cocktail mixing device is integrated into a full bar setup that gains utility by including a sink and cooling system, it seems to be warranted. Though this particular design provides a considerable amount of utility to the user, it seems more appropriate for use in a commercial rather than residential setting.

Each of these patents accomplishes functionally the same task of dispensing precise volumes of various ingredients to produce high-quality cocktails, but are all done in very different ways. By drawing from the inefficiencies of these patented designs, I will be able to better align the development of the design concept to that of user-focused experience.

2.4 Benchmarking

2.4.1 Physical System

I primarily focused on different automated cocktail mixing devices that have been developed in prototype form when benchmarking for this project. There weren't really any products on the market that addressed the issue of flexibility and versatility in handling a large number of ingredients to produce a large variety of cocktails, so a focus on prototype level devices seemed more consistent with my goals.

Several of these prototype level devices incorporated many of the design elements found in the patents for similar devices, as discussed in the previous section. Figure 5 shows four of the devices that were benchmarked, along with their name designations.

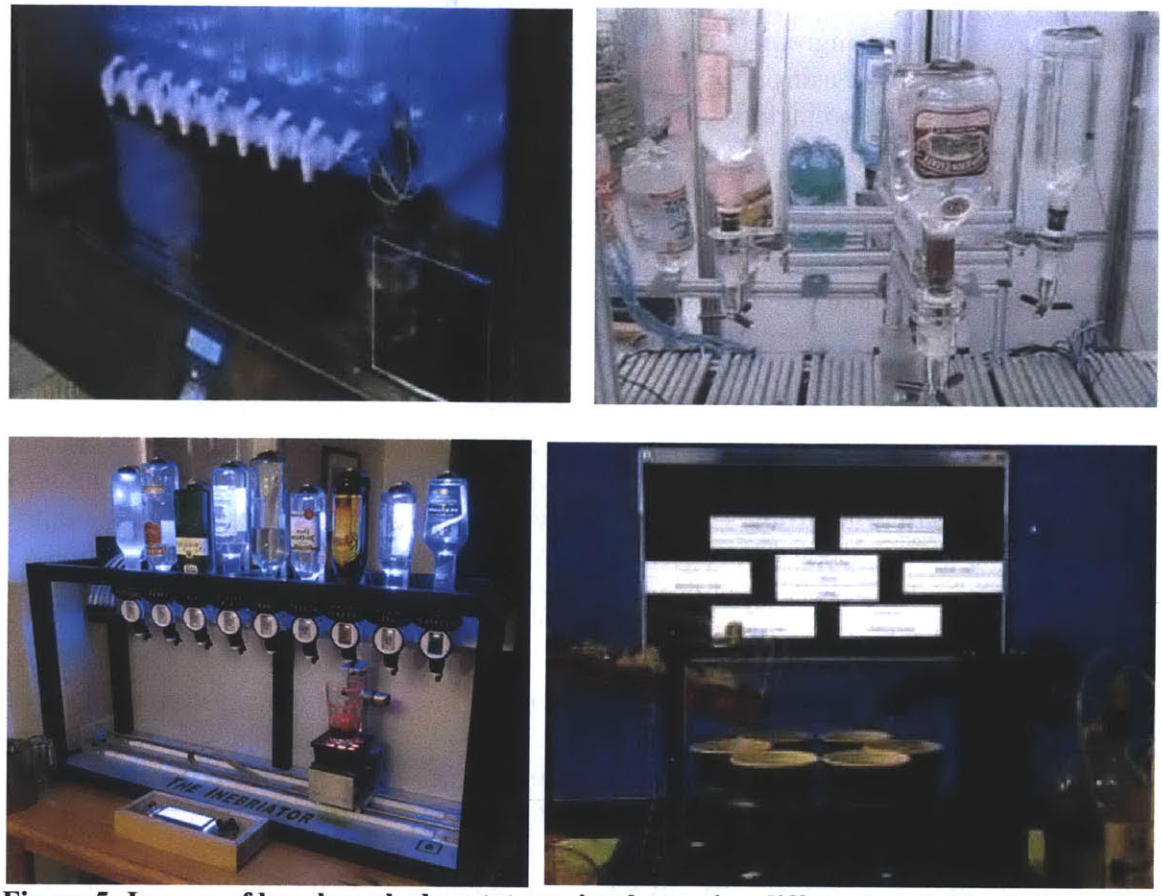


Figure 5: Images of benchmarked prototypes implementing different methods of dispensing alcoholic and non-alcoholic ingredients. (Top, Left to Right) Automated Mixed-Drink Dispenser [9] and Autobar [10]. (Bottom, Left to Right) Inebriator [11] and Francoit Barbot [8]

The Autobar device most closely resembled patent 1 from the previous section in that it consisted of two sets of rotating upside-down mounted bottle fixtures used for dispensing alcoholic and non-alcoholic ingredients as well as a conveyor belt for transporting a cup between stations. The inherent flaw with this design was that it took up too much space and implemented a higher degree of complexity than should be required, especially given that a robotic arm was used to initially fetch a cup. This meant that the user would only need to select a drink and wait while the device fetched a cup, loaded it with ice, moved it to the alcoholic ingredient station to filled, moved it to the non-alcoholic ingredient station to be filled then finally arrive at the location where the order was placed.

The Automated Mixed-Drink Dispenser and Inebriator devices both implemented similar systems for dispensing ingredients. A cup was placed on a single-direction translating platform, which would change position until it was directly under the ingredient station that was to be poured next. An actuator mounted on the translating platform would then open a valve on the station to release the liquid. The only difference between these two was that the Inebriator used

alcoholic ingredients in their original bottles mounted over the frame while the Automated Mixed-Drink Dispenser used separate containers to dispense its ingredients. Though there seems to be some aesthetic value in using the original liquor bottles to dispense ingredients, using separate containers would facilitate a more compact design that is not dependent on the size or shape of containers that the ingredients come in, whether alcoholic or non-alcoholic.

The Francois Barbot device allows users to load up to six cups at a time so that multiple orders can be placed at one time and have it toggle through each of the cups. This design uses a system of pressurized bottles full of ingredients and servo controlled pinch valves to determine which ingredient will be dispensed at any one time. In addition, a short conveyor belt angled at a decline was positioned over the cups such that ice can be placed on it and dropped into the cups. Though there is a convenience in being able to automatically fill a cup with ice, there would still be a great degree of user intervention required here because of the short length of the conveyor belt and therefore limited ice cube capacity. The alternative to this would be to integrate an ice-dispensing unit, but that could prove to be spatially unfavorable.

During the benchmarking process, I found that each of these prototype level devices did not deliver a user-centric design, which could be attributed to the fact that they were all in very early stages of development. These designs were either too large, required too much time to process an order or simply demanded more human intervention than should exist in such an automated system. In further search of a more developed product that was catered to an intuitive user experience, I came across a product that was at the time being launched on Kickstarter and has since then met and exceeded its funding [7]. Figure 6 depicts an early iteration and the final assembly of the device known as Bartendro.

Figure 6: Images of Bartendro in an early iteration (Left) and final product (Right) [7]

The Bartendro device had been in development for nearly two years prior to its debut on Kickstarter in March 2013. The final product in this series implemented a series of high-precision peristaltic pumps to draw known volumes of liquid from individual open containers and dispense them into the pouring area where all the tubing converges. At the point of convergence, however, the user must hold the cup under the feed source while selecting the drink

of choice through the interface, which is an inconvenience that could be fixed with a redesign of the frame. Though an early iteration of their product used the bottle-mounted system similar to that of the Inebriator, the inventors stated that by moving from a gravity-based, flow controlled feed to a peristaltic pumping feed they were able to drastically reduce the size of their original design and see gains in precision. In addition, the device uses a Raspberry Pi to deploy a wireless network that allows users to connect to the interface using any WiFi-ready device, which I will discuss further in the next section. At a cost of $1,300 for the 7-pump system and $2,300 for the 15-pump system, this device still seems to fall under the high-end category of cocktail accessory products.

Through the investigation of these different devices, I have been able to apply a number of different design considerations to the development of the physical device concept. The use of LEDs to draw attention to the device containers or pumps was a useful aesthetic addition, though it would be better served to use them to draw attention specifically to the containers that are being drawn from at any given moment. Most of the devices did not incorporate any kind of shaking or stirring mechanisms, so it could be the case that it is not necessarily important to add this extra degree of complexity; this is consistent with the "rules" applied by bartenders in that most recipes do not actually need to be physically agitated. By observing the operation of these devices, it became clear that there were a number of functional details that could have been adapted to greatly enhance the user experience. These additional functional qualities will be discussed in greater detail in section 3.

2.4.2 User Interface

In addition to benchmarking physical automated cocktail mixing devices, I also investigated the user interfaces that were applied to them as well as digital applications that present users with extensive categorized databases of cocktail recipes. The reason I chose to include the category of cocktail recipe digital applications was rooted in an understanding that a product with the functionalities of an automated cocktail mixing device is most attractive to individuals who are enjoy and are interested in cocktails, but do not necessarily have the knowledge or experience to make their own recipes without a reference. By integrating the referential qualities of these digital applications as well as existing user interface models, it would be possible to cater to users who want to learn about cocktails, not simply enjoy them.

One of the best digital applications I found while benchmarking was called Cocktail Flow, which gave users access to over 100 recipes for free (with more available for purchase). The mere size of the database, however, was not the most attractive feature of this application. Users can input every alcoholic and non-alcoholic ingredient they have available in their home bar and Cocktail Flow will output every possible recipe that can be made with that combination of ingredients. If a user wanted to pull up a list of recipes that used a specific ingredient or that resulted in a certain color, a few taps of the screen would prompt Cocktail Flow to filter through its extensive database of recipes and present the relevant ones to the user. Figure 7 shows a set of screen shots of the Cocktail Flow user interface that allows users to select the ingredients available in their home bar. This method of dynamic database filtering would work well in collaboration with an automated cocktail mixing device because it would allow the user to simply input the available ingredients and produce a list of recipes; or it would be possible to

also work in reverse and select a list of recipes and output the ingredients required to create those cocktails.

Figure 7: UI of the Cocktail Flow digital application dynamically filtering database [12]

The secondary focus during benchmarking the previously discussed prototype level devices was that of the user interfaces that were integrated into them and the resulting user experience in the form of available functionalities.

The previously discussed Autobar implemented a profile-based system that required the user to swipe an ID card, serving the purposes of both age verification and pulling up a drink history of that particular user. This functionality would be particularly useful if the user wanted to select the same drink again or to track the drink preferences of different users and use that information to adjust ingredients for future use.

The Francois Barbot implemented an interesting UI feature that somewhat contradicts the "rules" of a systematic bartending methodology, giving user more flexibility in the creation of drinks by prompting them to determine what volume of each liquor would go in each recipe. Because that particular UI did not pull recipes from a database, this seems like an acceptable feature to give users more control as to how strong they want their drinks to be, but it does not provide the user with the vast recipe and systematic portioning knowledgebase that a bartender would have. Another feature implemented by both the Francois Barbot and Bartendro was that of a wireless connection through a web application to place orders. The only difference between the two was that Francois allowed individual users to access the drink ordering system through their own wireless devices, adding their request to the queue of drinks, whereas Bartendro worked by wirelessly syncing and physically mounting a single tablet or smart phone device to serve as the main interface for all users involved. Making the ordering system accessible to any user through their device only seems appropriate for the particular system it is applied to, but it would not really make sense for a system that serves one drink at a time such as that of Bartendro. Furthermore, requiring a secondary device presents a major constraint if the user does not have a compatible device or it isn't charged, making this a fairly unreliable design direction.

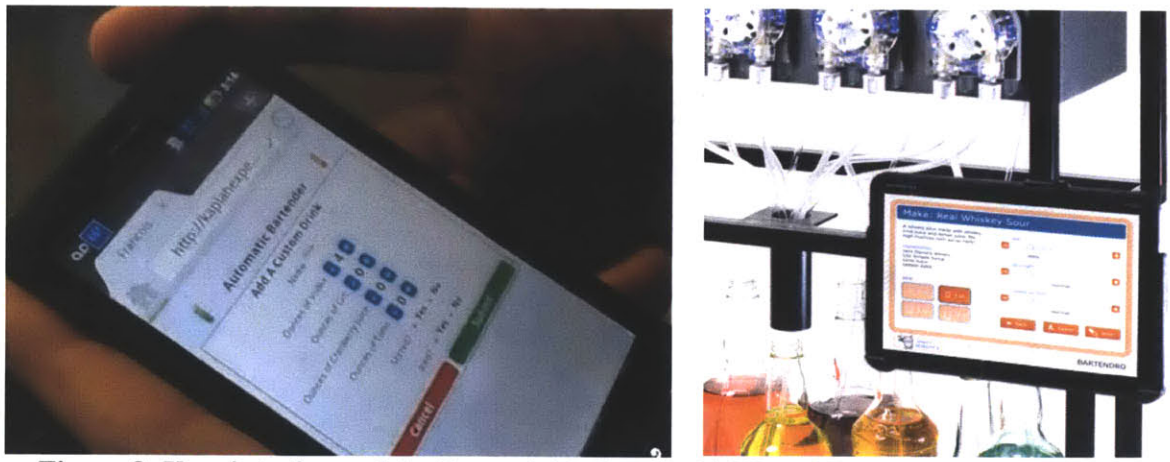


Figure 8: User interfaces of the Francois Barbot (Left) [8] and Bartendro (Right) digital applications [7]

2.5 Market

2.5.1 Target Market

There are a variety of different markets in which an automated cocktail mixing device could be marketed toward, but for the purposes of defining a clear use-scenario to drive design concept development I decided to focus on the home bar accessory. As a customer base for the purposes of the design concept development, I surveyed a group of legal drinking aged undergraduates and alumni of my living group.

If this product were taken to market, it would have the potential to target three different market sizes. The first would be that of young individuals between the ages of 21 and 34. According to a 2010 study conducted by Gallup, 72% of individuals in the 21 to 34 year old demographic have occasion to consume alcohol. Furthermore, 24% of these individuals who identify themselves as drinkers prefer to consume liquor/cocktails. According to the 2010 U.S. Census data, this target demographic consists of 11 million individuals. If the automated cocktail mixing device design concept was taken to this market, it is likely that it would develop into a much more compact form so as to fit into the limited space on a home bar or kitchen counter. [3] [4]

A second possible target market is that of caterers that incorporate an open or cash bar into their offered services. According to an IBISWorld report, the U.S. catering industry is a $7.7 billion industry and is made up of over 9,000 catering enterprises. If the device was to be adapted to this market, the spatial constraints would not be quite as stringent as in the case of a home bar setup. By using a set of automated cocktail mixing devices at a catered event, the catering company has the ability to off-load the work of a bartender to a machine as well as implement age verification, electronic payment systems and inventory tracking. [5]

A third possible target market is that of bars and nightclubs as a means of off-loading the work done by a bartender. According to another IBISWorld report, the U.S. bar and nightclub industry is a $19.8 billion industry consisting of over 70,000 establishments. 32.5% of the total revenue is attributed to the sale of cocktails, a segment of the industry totaling $6.5 billion. This market would have the most barriers to entry because it is an already standardized model and lack of automation technology. [6]

2.5.2 Pricing

In order to gain insight into the pricing constraints that will limit most potential consumers from purchasing an automated cocktail mixing device, I surveyed the previously mentioned group of students and alumni from my living group on the pricing aspects of this device. The design concept was presented to the participants as a device capable of automatically pouring various ingredients from alcoholic and non-alcoholic ingredient sources to create a variety of cocktail recipes. Participants were then asked a series of questions that clarified the potential for an extensive list of additional functionalities to be integrated with the basic design concept of the automated cocktail mixing device. After developing a clear idea of the potential functionalities of such a product, participants were asked what they would be willing to pay for a device of the defined functionalities. 37% of participants reported to be willing to pay between $100 and $200 for the device. 48% of participants reported to be willing to pay between $200 and $400 for the device.

Relative to the high price point for the Bartendro device of $2,300, a $400 automated cocktail mixing device would seem quite affordable. The Bartendro device is approximately 500% more expensive than what potential consumers claim to be willing to pay, so it is clear that there is a need for a new design that will drive the cost to the consumer far down enough to make it feasible for the automated cocktail mixing device to make its way to the end user.

Design Concept Development

3.1 Design Concept Considerations

Upon completing a thorough investigation of the functionalities, positive and negative attributes of various automated cocktail mixing prototypes, I moved on to brainstorm the types of mechanisms that would work best as the most critical module (dispensing method). Just as with the development of any product concept, there are a variety of possible directions one could follow, it was simply a matter of following the path that offered the most potential for an intuitive and positive user experience.

The primary focus of the initial brainstorming stage of the concept development was to consider every possible way of getting liquid ingredients from one location to another, including those methods that were observed in the benchmarking process. I decided not to discard the observed mechanisms altogether because I felt that even if one of them was the absolute best method, there would still be other changes to the design that would could improve the device's functionality. These observed mechanisms included upside-down mounted liquor bottle system using gravity feed and valve system, separate containers filled with liquid using gravity feed and valve system, parallel arrangement of pressurized liquor bottles with pinch valves controlling flow and an individual pump system drawing liquor directly from each open bottle.

Before the brainstorming process, I defined a few attributes of the automated cocktail mixing device that would help keep a focus on the necessary qualities of the most critical module. First was that of precise pouring capabilities. As I found out during my first-hand bartending experience, most recipes used increments of ½ ounce (approximately 15 mL) for their alcoholic ingredients. If one or more ingredients in a recipe deviated from the prescribed volume by even 5 mL, it could alter the taste of the drink in a way that was not intended, possibly producing a less than desirable flavor. The second attribute to keep in mind was that of the liquid source removal. Because this source of liquid, whether the original bottle or a separate container, would more than likely need to be removed to be stored, refilled or even replaced, it stands to reason that ensuring that the basic design concept addresses this is a critical need. The third attribute was that of physical space occupied by the device. Each of the dispensing mechanism considered have different design requirements that will factor into the final size of the product, which should be minimized for the convenience of the user.

From the various dispensing mechanism concepts brainstormed, three were chosen so that further investigation of each of their merits and pitfalls could be conducted. The first dispensing mechanism was a multi-pump system that uses a single pump to draw liquid from the top of a single separate container. This particular concept most closely resembles the Bartendro device in its use of a single pump for a single liquid source. Instead of using the original bottles that ingredients are sold in, however, this design would integrate a series of individual containers in which the user can pour the desired ingredients. By including the liquid source containers into the design, it will eliminate the need of leaving an open space under the device that results in an overall large and bulky product.

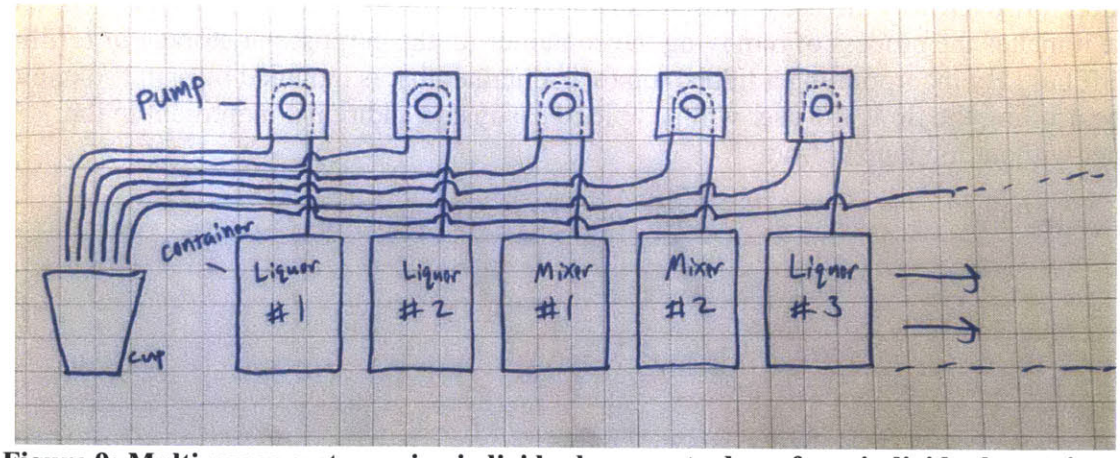


Figure 9: Multi-pump system using individual pumps to draw from individual containers

The second dispensing mechanism concept was a single-pump system that uses only one pump to draw from all liquid sources, using solenoid valves on each of the liquid source flow paths to limit all flows except for the one that is desired at any given moment. This concept somewhat resembles the mechanism of the Francois Barbot, which used a single pressure source connected to all liquid sources to drive all of the flows forward and a pinch valve on each of the liquid source tubes to limit the flow of the undesired ingredients at any given moment. The reason I decided to move forward with the "pull" system of a single pump at the outlet end of the flow rather than the "push" system of a pressure source at the other end of the flow was that the latter method would require that the containers be completely sealed from the atmosphere to allow the build-up of pressure that drives the flow. Requiring that each of the containers be sealed would cause an issue when the user has the need to remove the container for storage or refilling.

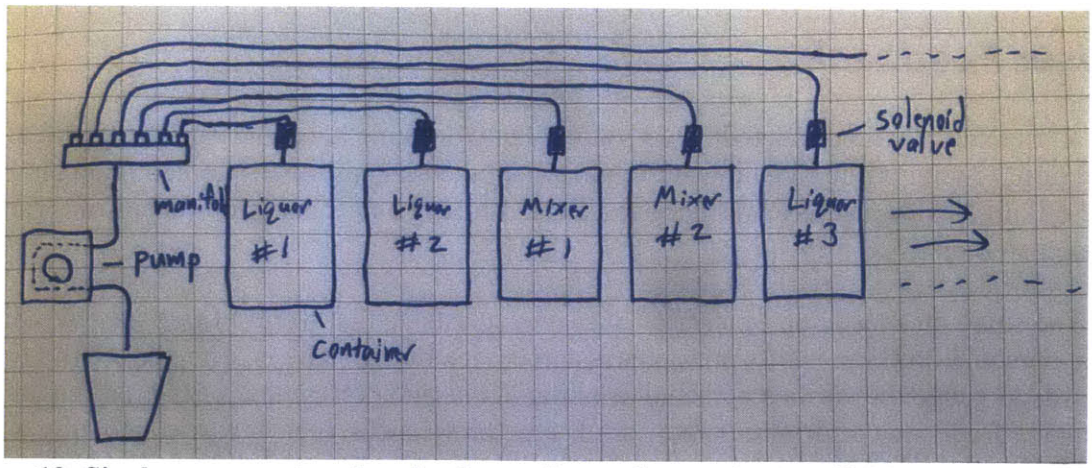


Figure 10: Single-pump system drawing from all containers using manifold and solenoid valves

The third dispensing mechanism concept was a pump-less system with each container, having a lidded top, mounted over a solenoid valve that uses gravity feed to produce a natural flow of liquid. This concept closely resembles that of the Automated Mixed-Drink Dispenser and Inebriator, which incorporate gravity feed and valve actuation to control the flow of each of the loaded ingredients. One of the issues with the way this design concept was implemented in the

Inebriator, however, was the use of upside-down mounted bottles as the liquid source containers because it makes the process of removing the container for the purposes of storage or refilling more difficult. By incorporating a lidded top to a container that is mounted over the solenoid valve controlling the flow, the user will be able to easily add additional ingredient to the container without too much effort.

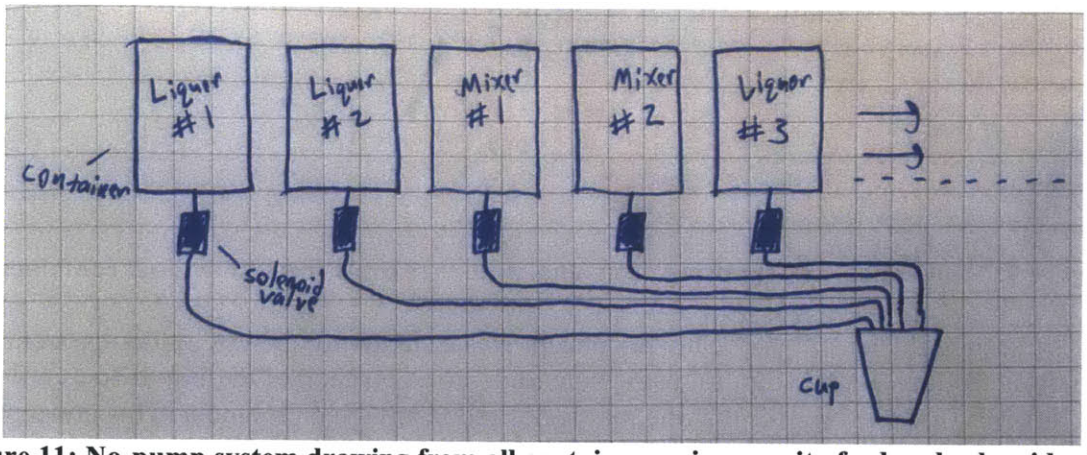


Figure 11: No-pump system drawing from all containers using gravity feed and solenoid valves

Now that three possible mechanism concepts have been clearly defined, the next step is to determine which direction should be chosen to further develop the design concept and explore other detailed design requirements and higher-level functionalities. Before moving on to this step, however, it was important to take measures to ensure that the direction chosen could best meet the needs of the end-user. Gaining feedback about the types of basic and higher-level functionalities that users feel is critical to the device proved valuable in defining the direction that should be followed.

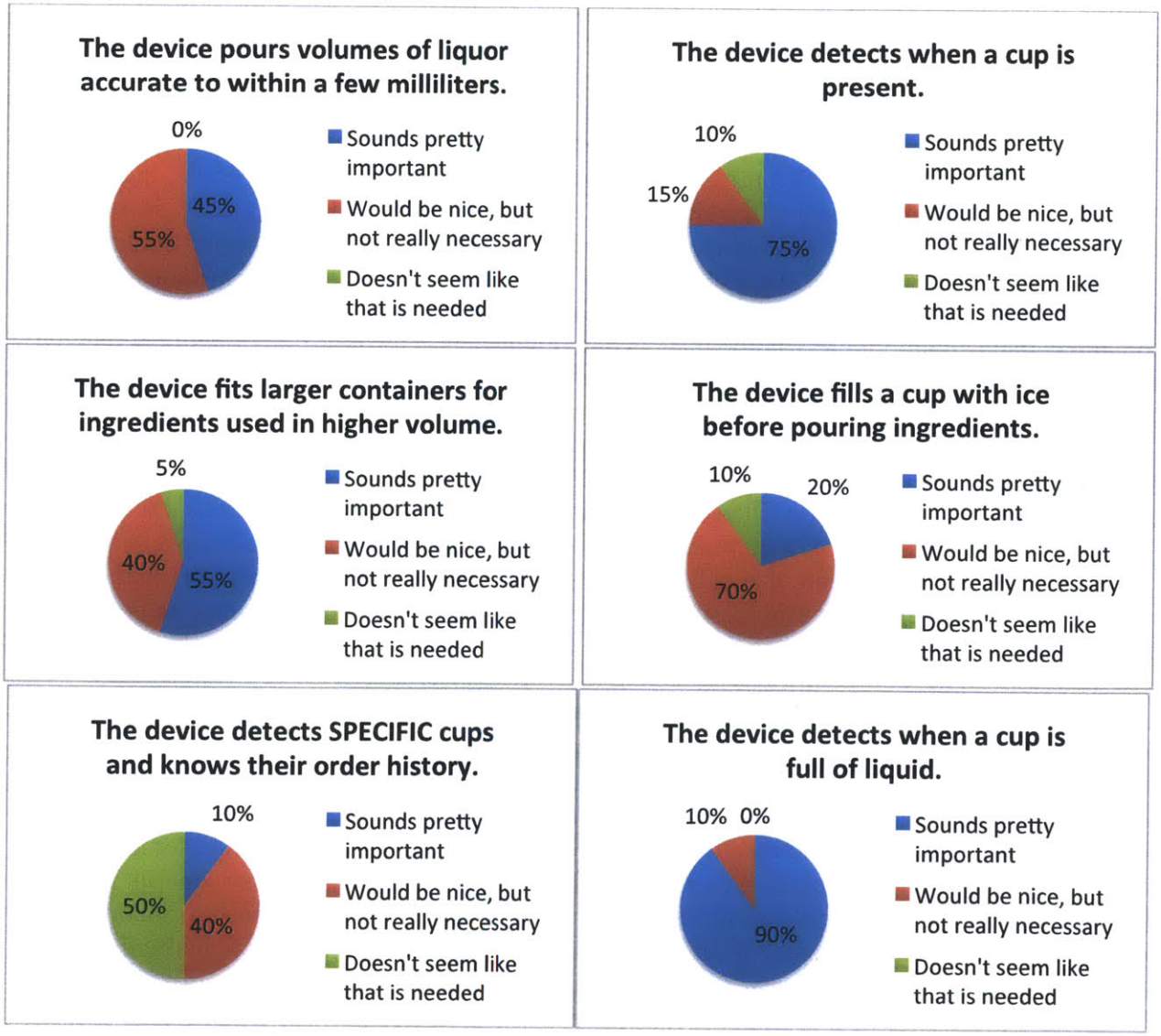
3.2 User Feedback

A user study was conducted on a group of legal drinking aged undergraduate and alumni member of my living group to gain insight into what potential customers wanted in an automated cocktail mixing device and to learn more about the drinking habits and preferences of these potential customers.

The study was made up of a series of survey questions that were split up into two distinct sections: personal drinking habits/preferences and device functionalities. The goal of the first section was to gauge the various personal drinking habits and preferences of the participants, including the frequency of drinking, their drink-type preferences, their favorite alcoholic and non-alcoholic ingredients to use in cocktails as well as their perceived level of experience with making their own mixed drinks. By posing these questions, I would be able to get the participants thinking thoroughly about their own drinking experiences, putting them in a better position to answer the questions of the second section, which was that of device functionality.

The goal of the second section of the survey was to present the participants with a clear, but non-specific, idea of what an automated cocktail mixing device was. The design concept was

described as a "device capable of automatically pouring various ingredients from alcoholic and non-alcoholic ingredient sources to create a variety of cocktail recipes." Next, participants were presented with a series of possible device functionalities and qualities and asked whether or not they felt this was a critical attribute of the automated cocktail mixing device product. In order to prevent participants from simply stating that all device functionalities that were inquired about was critical, I had to stray away from a simple binary response. Because each of the participants had their own experiences in drinking environments that would drive their opinions about what was necessary, what would be interesting to see but didn't seem like a requirement and what was just an added, unnecessary degree of complexity, I defined the response options as three statements consistent with this idea: "Sounds pretty important", "Would be nice, but not really necessary" and "Doesn't seem like that is needed." Figure 12 shows the response distribution for each of the device functionalities that were presented for the automated cocktail mixing device.



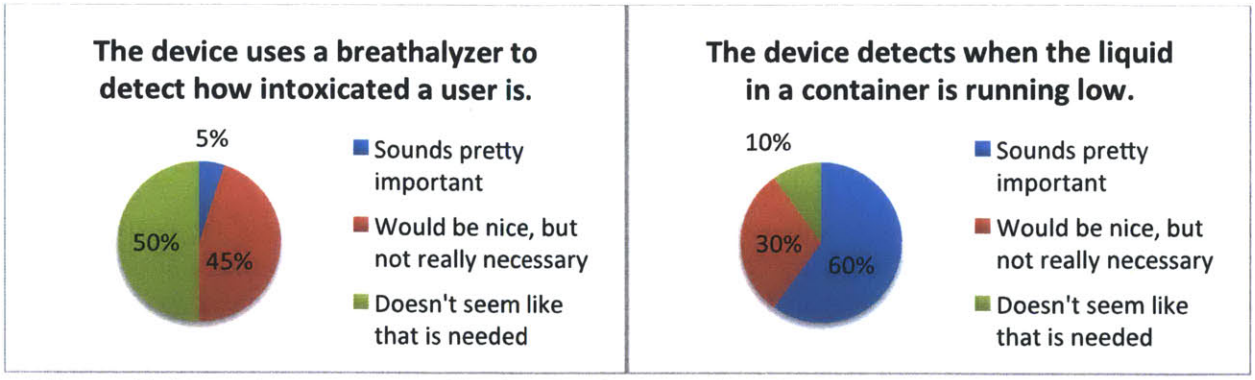


Figure 12: Participant response distribution for perceived importance of device functionalities

Of the eight different device functionalities that were presented to the survey participants, it appears that only four are perceived to be critical by potential users. The first of these is the detection of a cup that is placed into the device. This particular function would allow the implementation of a "dead man's switch" feature that would only make it possible to dispense ingredients when a cup has been placed under the flow path. The second critical functionality was that of the device being compatible with various sized containers in order to accommodate the non-alcoholic ingredients that might be used in greater volume than the alcoholic ingredients. A simple one-liquor drink such as a screwdriver, containing vodka and orange juice, is made with 1 part alcohol and 3 parts orange juice. In the case that a user was planning on serving only screwdrivers at an event, he or she would have to load orange juice 3 times the volume of the available vodka to meet the required ratio, so it would be useful for there to be available mixer containers that can hold more volume than alcohol containers. The third functionality perceived as important by survey participants was that of detecting the amount of liquid already in a cup so as to ensure that the device does not cause the contents of a cup to spill over. This particular function could be used as a feedback system to inform the device that it is done pouring a given recipe or even as a secondary "dead man's switch" feature that restricts the device from pouring additional liquid into an already filled cup. The final functionality considered critical was that of detecting when the contents of a particular container. This particular functionality could allow the implementation of a feature that calls the users attention to the specific container that is running low so that it can be refilled, which would be much preferred over running out of a key ingredient in the middle of pouring a recipe.

Among the presented functionalities, however, there were also those that participants predominantly viewed as being an unnecessary degree of complication. Specifically, the functionalities of detecting when specific cups are replaced into the device to know their drink order history and of using a breathalyzer to determine the level of intoxication before serving a drink. The latter presented functionality would present a cumbersome step in the user interaction and did not serve a critical purpose, particularly for the case of a home bar use scenario. The detection of specific cups would allow users to create profiles that recorded each drink order they placed, making it easier to choose from their favorites during their next order. Initially thoughts on this functionality made it appear to be a necessary attribute to enhance the user experience, but the user study has helped determine otherwise.

To my surprise, I found that many participants felt that high-precision pouring would be an interesting addition to the device functionalities, but was not particularly necessary or didn't offer any clear advantages to the user experience; this finding was strongly taken into consideration during the design concept selection process. The ice-filling functionality also gained significant feedback in the category of "would be nice, but not really necessary" most likely because users felt that it would be minimally time and effort intensive to fill their cups with ice themselves. This information too will alleviate design problems in the future in that adding an ice dispensing device to the cocktail dispensing device will not be necessary, which most likely would have exceeded ideal spatial constraints.

After gauging the perceived level of importance of these functionalities, participants were asked under which use-scenarios this type of device would be best suited for. The three different markets that were presenting in a previous section were presented and asked to determine if this was an appropriate use-scenario for the proposed device with given functionalities. 85% of participants considered the home bar accessory for personal use or for small gatherings to be ideal. 60% of participants agreed with the use of the device at a catered event where it is supplied as part of the catering service. Only 25% of participants, however, felt that a bar would be an appropriate place to integrate such a device. The reason for such a low approval rating for this particular use scenario is most likely rooted in the way bars are so standardized, making it very difficult to consider a complete overhaul of the way patrons are served drinks. This is consistent with the idea that this market segment would have the most barriers to entry.

3.3 Selecting a Design Concept

The information gained through the user study provided a much needed degree of insight during the design concept selection process, and could also play a key role in future development of this product. Though each of the discussed functionalities was not taken into direct consideration when comparing the three different proposed mechanism concepts, it was still important to have a clear understanding of what the device would be expected to be capable of doing before following a path to a more developed design concept.

The first step of the selection process was to develop a set of criteria by which each of the mechanism concepts could be compared to each other. After careful consideration, six criteria were defined that would help determine which mechanism would best serve the user experience. These were potential *cost to the user*, *power consumption of the device*, *precision pouring capabilities*, *maintenance, usability*, *overall size* and *speed of processing a drink order*. Once these criteria were defined, the next step was to compare each of the mechanism concepts against each other using a Pugh Chart (shown in Figure 13) to visually observe the strengths and weaknesses of each. The three mechanism concepts being compared were (1) a multi-pump system that uses a single pump to draw liquid from the top of a single separate container, (2) a single-pump system that uses only one pump to draw from all liquid sources, using solenoid valves on each of the liquid source flow paths to limit all flows except for the one that is desired at any given moment and (3) no-pump system with each container, having a lidded top, mounted over a solenoid valve that uses gravity feed to produce a natural flow of liquid. The multi-pump system was used as the standard on the Pugh Chart because it closely resembled the Bartendro device, which I knew the most about.

	Multi-Pump	Single-Pump	No-Pump
Cost	0	+	+
Power	0	0	+
Pouring Precision	0	0	−
Maintenance	0	+	+
Usability	0	0	+
Size	0	+	+
Speed	0	−	0

Figure 13: Pugh chart of potential mechanism concepts for dispensing liquid ingredients

Though each of the mechanism concepts are reasonable, they each have one or more fundamental flaws that would cause limitations in some aspect of functionality. For this reason, it is necessary to select the concept in which the flaw detracts the least from the user experience. For the single-pump system, the ingredients must be poured one at a time because it uses a single pump to draw from all available liquid sources. In most cases, alcoholic ingredients can and should be poured simultaneously to speed up the drink order process, which both the multi-pump system and no-pump system will be capable of because each of the liquid sources has its own individual dispensing mechanism.

The multi-pump system faces both cost and maintenance issues, largely due to the use of a large number of pumps. As we saw with the Bartendro, its only critical components were the custom peristaltic pumps that were used to draw and dispense liquid, which was a large factor in the $2,300 price point for a 15 pump system. The single-pump and no-pump systems, however, would only require the use of as many solenoid/pinch valves as pumps would be required in the multi-pump system (as well as one pump for the case of the single-pump system). Based on price points from various electronic component suppliers, using predominantly solenoid/pinch valve systems rather than pump systems would be most cost effective. With the use of so many pumps also come issues with maintenance of these components. Particularly because the application requires the pumping of various different types of liquids, ensuring that so many components are always in good working condition and replacing them if necessary would be too burdensome on the user.

The no-pump system's main flaw is that of uncertainty in being able to pour known volumes of liquid consistently. With pump driven systems, it would be possible to associate each revolution of the motor with some known volume based on testing and calibration. Whether a solenoid valve or a pinch valve is implemented to limit the flow from a container, there is no inherent method of measuring volume as there is with the pump system. The options available given this system would be to use an open-loop system dependent simply on the time a valve is

open to determine the dispensed volume or to use a closed-loop feedback system that implements a flow meter within the flow path to instruct the valve exactly when to close. The open-loop system would likely be less precise than the closed-loop system, but the closed-loop system would require the addition of a flow sensor for every liquid source container on the device, which would drive up the cost to the user. Based on the feedback concerning the importance of a precision pouring functionality gained through the user study, however, it was made clear that users to not place a very high value on the precision in which ingredients are dispensed into the cocktail. With that in mind, it may be most beneficial to simply use the original solenoid/pinch valve system as is and incorporate a simple timing control.

Because the last mechanism concept discussed offers the most advantages based on the presented criteria, I decided to move forward in the design concept development process with this gravity feed and solenoid/pinch valve flow controlled system. With a mechanism concept selected, the next step would now be to develop a potential form factor for the design concept that could drive future development.

3.4 Design Overview

In developing a form factor for the automated cocktail mixing device design concept, it was important to consider the different options for the physical manifestation of the product, in both shape and size. One consideration was to use a rectangular form factor similar to that found in the Bartendro and Inebriator devices, in which ingredients are lined up in the longwise configuration. This form factor would allow users to setup the device on a countertop flush against a wall, next to a wall outlet. One problem with this form, however, is that no matter where the tubing convergence point for cup placement is, the tubes leading from the liquid source container to the cup will likely be of different lengths. The reason this is important is that the open-loop timing system implemented into the device will have to account for the fluid travel time between the valve and cup, not only between the liquid container and the valve. For varying lengths of tubing, individual calibrations would need to be made to determine the duration of time required in opening the valve for each different length. This presents issues both in future product development and testing stages as well as complicating the user experience by having to make sure the tubing is not tampered with or switched around between containers, making it an all around cumbersome design choice.

In a gravity feed system such as the one that is being developed, it is ideal to not only ensure that each tubing segment is of the same length, but also that the length is minimized as much as possible to reduce the volume of ingredients that are held in place between the valve and tube opening. When such a valve is closed after pouring some volume of ingredient, liquid is retained in the tube due to a restriction of airflow that would promote liquid flow, just as is the case when a straw is lifted out of a glass of water while holding a finger over one end.

Given these two requirements of short and equal lengths of tubing coming out of the liquid source container, the clear alternative to the rectangular/linear design configuration is that of a circular/cylindrical configuration. By mounting the liquid source containers and valves in a circular pattern over an area where a cup is placed, the lengths of the tubing are equal and effectively minimized. In order to communicate the details of this particular form factor, and the

design concept as a whole, a CAD model of the automated cocktail mixing device was created (shown in Figure 14).

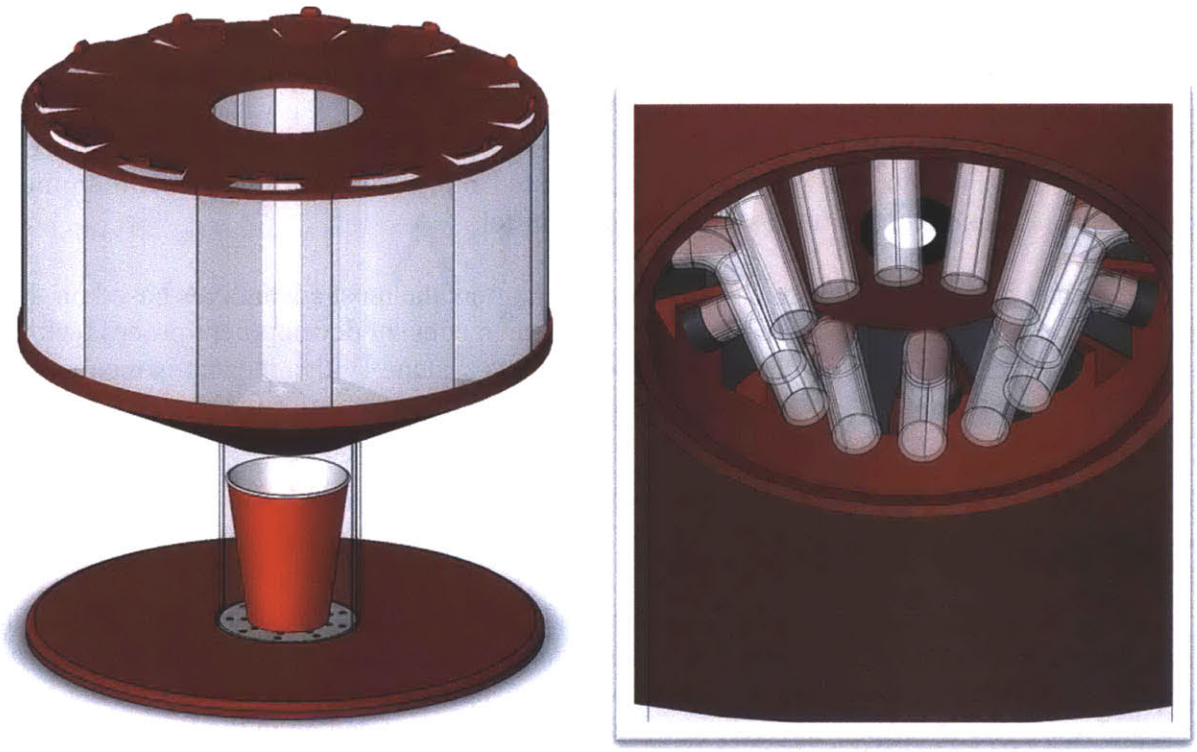


Figure 14: CAD model of circularly symmetrical form factor (Left) and close-up view of underside of the device where the flow tubing is positioned over a cup (Right)

The design concept, as illustrated in Figure 14, consists of a plastic circular base platform with a circular indentation at its center where a metal spill plate and plastic vertical supports can be attached. Atop the plastic vertical support is a plastic symmetrical frame that holds 12 liquid source container/flow control valve modules, which are shown separately from the whole device in Figure 15. The liquid source container has a lid on its top, which can be opened so that the user can easily refill it when an ingredient is nearly depleted. At the bottom of each container is a spring-loaded nozzle that is normally closed, allowing it to restrict the flow of any liquid out of the container. When the container nozzle is interlocked with the black box device shown under the container, the spring-loaded nozzle will open, allowing flow across the container-black box interface. Inside the black box, between the interlocking interface and the tubing outlet directing flow into a cup, is a valve system that can consist of either an off-the-shelf solenoid valve or a custom-made pinch valve made from an off-the-shelf serve actuator, a spring and flexible tubing. The detailed design of the black box has been omitted from this thesis for the purpose of focusing efforts on the user experience rather than detailed mechanical design.

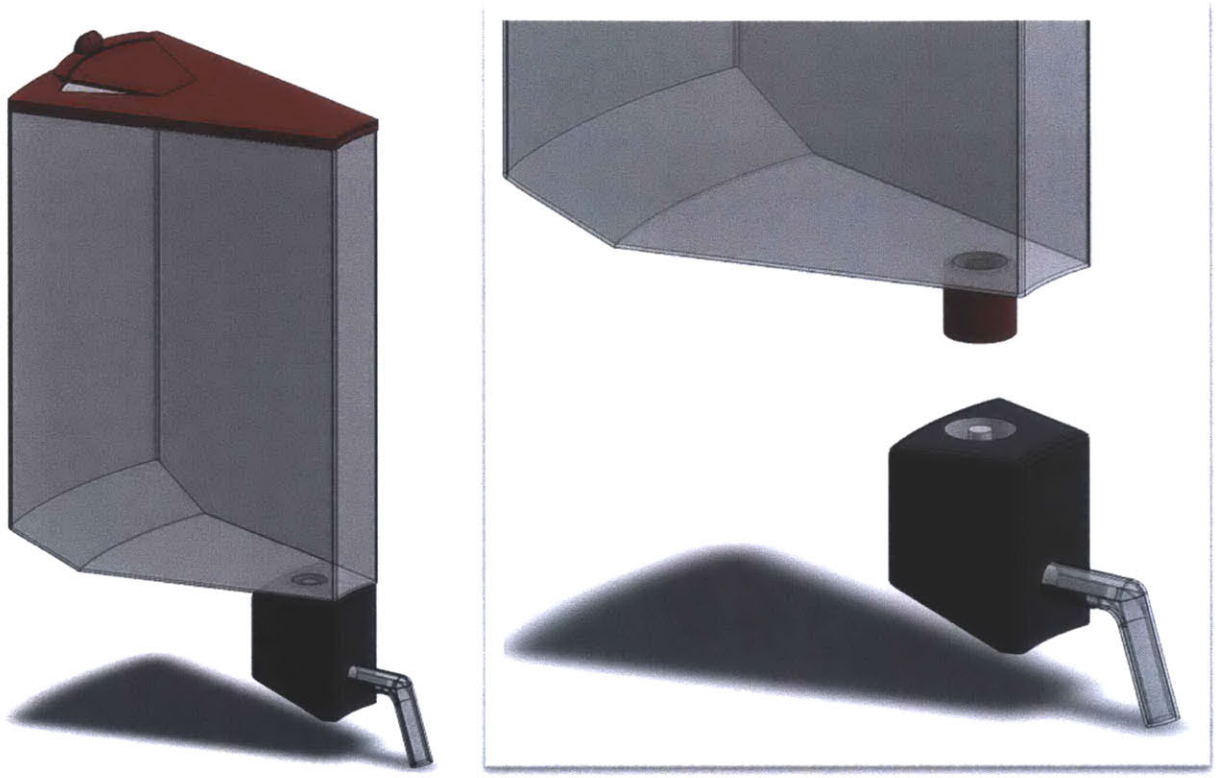


Figure 15: CAD model of liquid source container/black box module in both interlocked (Left) and separated (Right) configurations

The current design dimensions are approximately 16" by 16" by 20" tall, including the containers. Each container, in its current state, is approximately 4 inches tall and can hold nearly 1 liter of liquid. The container can be redesigned to hold more liquid by increasing its height without changing the design of the lid or nozzle interface. This gives this design the flexibility to create different sized containers so that users can use larger containers for non-alcoholic ingredients, which get depleted the quickest, and use the smaller containers for alcoholic ingredients, which will be depleted at a smaller rate.

One of the functionalities described in the user study that participants responded positively to was that of detecting when a cup is present in the device so that it can serve as a "dead man's switch" that would restrict any flow of liquid when there is no cup present. The first method of accomplishing this that was considered was using a force sensor pad to determine when a cup was placed in the device. Based on the commercially available force sensor pads, however, it would be very difficult to detect the presence of commonly used plastic cups because the detection threshold of the sensor was too high. A more reliable method of cup detection would come from implementing a photosensor and light source. Figure 16 shows a photosensor positioned under the metal spill plate where a cup would be placed. By installing a downward facing light source above the space where a cup would go, the system can be programmed to illuminate while the device is powered on. If a cup is present and the photosensor is blocked from the light source, the system will know that an order is ready to be processed. If a cup is not

present, however, the photosensor will be exposed to the light and restrict the flow of any ingredient even if the user attempts to process a drink order.

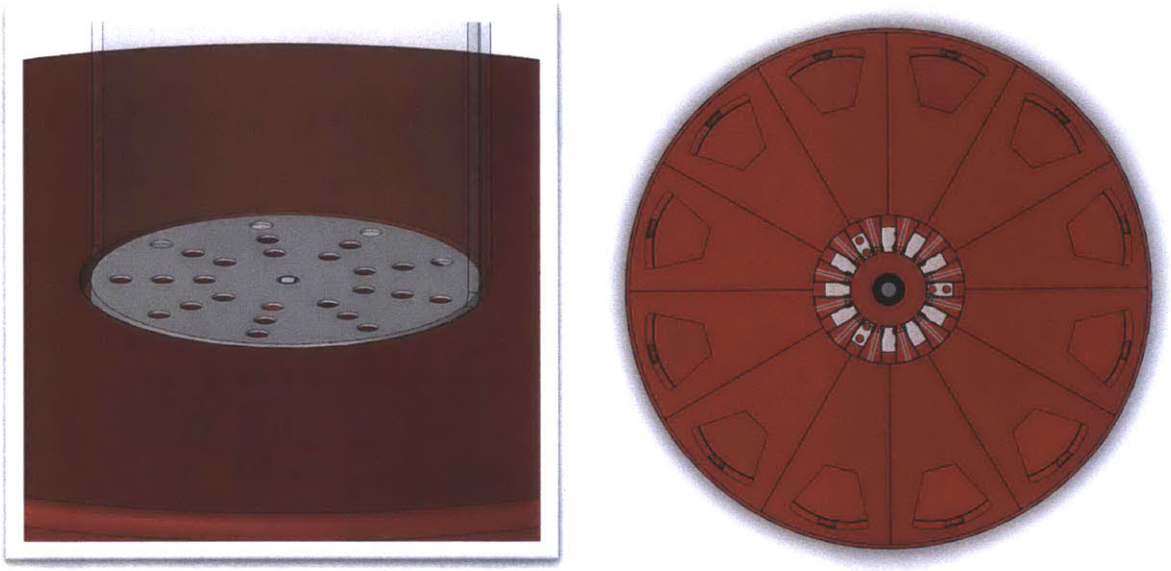


Figure 16: CAD model of lower base platform with photosensor positioned at the center of the metal spill plate where a cup would be placed (Left) and a top view of the whole device where a light source module can be seen mounted at the center of the upper plastic symmetrical frame

User Interface Concept Development

4.1 UI Functionality Considerations

A physical system with the functionalities as defined in the previous section has the potential to greatly enhance the user experience, but without the presenting the user with an intuitive and convenient user interface and database system, the user experience will suffer. The motivation behind designing this device in the first place was to find a way of harnessing the knowledgebase commonly found in a bartender as well as the convenience one experiences when he or she orders a drink at a bar, making it easily accessible to the user. The focus of the user interface should therefore be not only to provide convenience to the user, but also to *educate* the user about ingredient qualities/attributes and cocktail mixing methodologies applied by bartenders.

Aligning with the focus of educating the user about bartending methodologies, the systematic method of creating different drink types through prescribed portioning of the included ingredients I learned from the Drink Master Bartending School was further considered. As discussed in an earlier section, applying this system to a database of recipes defining the different ingredients in each drink would normalize the method through which the ingredient portions are defined in each drink. To accomplish this, each ingredient used in the device should have to be defined under one of three categories: liquor, liqueur or mixer. Mixer includes all non-alcoholic ingredients that are used in recipes such as orange juice, cranberry juice, cola, tonic water, etc. The main difference between most liquors and liqueurs is that the latter is infused with additional flavors and sugar resulting in a sweet taste, while the former is typically a more potent drink that is not sweet to the palate. The importance in making this particular differentiation in the system is because of a particular drink type that uses 2:1 proportions rather than 1:1 when only two ingredients are used (liqueurs, having lower alcohol content, would be added in smaller volumes than the accompanying liquor). In addition to defining each ingredient into one of the above categories, different qualities could be attributed to each different ingredient that would further expand the educational aspect of the user interface. Each ingredient could be defined by its flavor, alcohol content, calorie count, recommended substitutes if that ingredient is not available as well as some basic background information about the ingredient that will further inform the user about the cocktails he or she is drinking.

Another functionality resulting from implementing this system is that of allowing users to add their own recipes to the drink database. By simply selecting the ingredients the user would like to include in a recipe, the system could automatically calculate the appropriate proportions and volume of each ingredient ingredient based simply on the ingredient categories and number of ingredients. This serves as an effective method of *teaching* the user about the systematic cocktail mixing process used by bartenders.

Each of these functionalities makes for interesting user-device interactions, but it is not clear whether they will enhance the overall user experience. In order to align the user interface with the needs (and wants) of the user, UI specific questions were posed in the previously discussed user study.

4.2 User Feedback

In addition to the user study questions regarding the importance of various physical device functionalities, participants were asked to express their perceived importance of different UI functionalities. Figure 17 shows the response distribution for each of the UI functionalities that were presented for the automated cocktail mixing device.

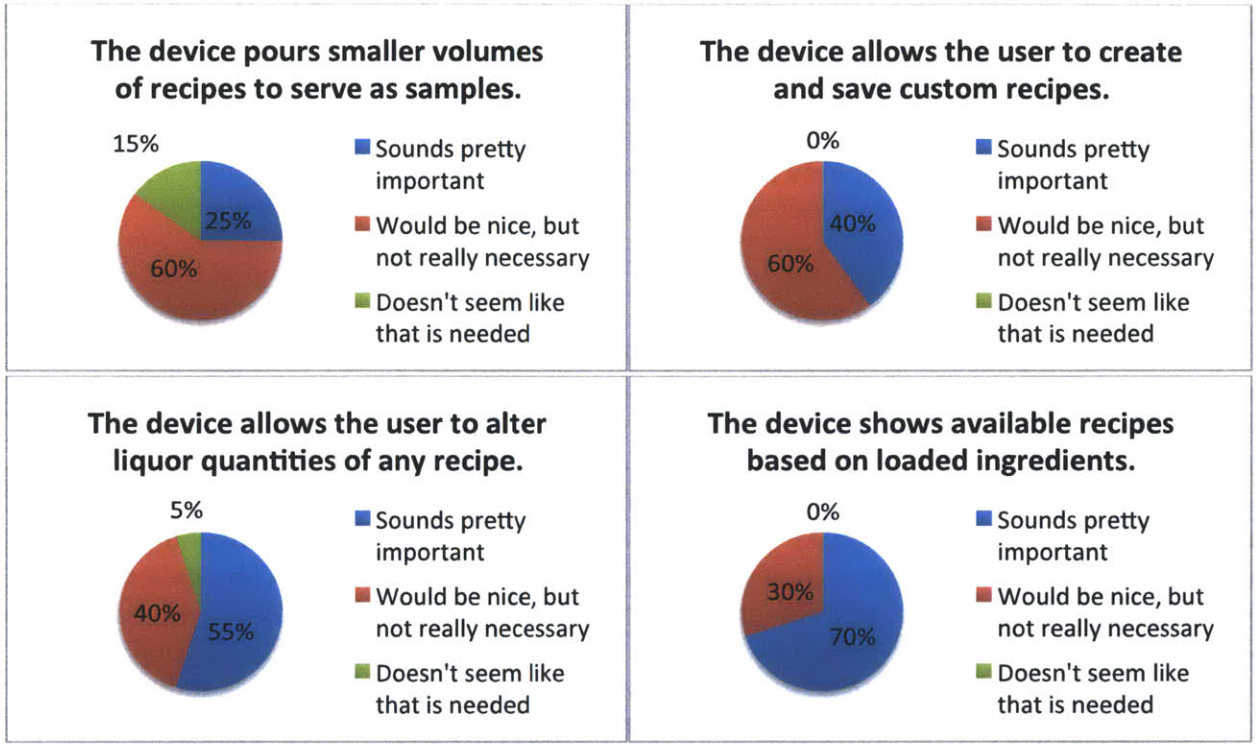


Figure 17: Participant response distribution for perceived importance of UI functionalities

Of the four main UI functionalities that were presented to the survey participants, it appears that all are considered, to some degree, to be a critical component of the user experience. Though approval was seen in each of the UI functionalities, it was observed that two of them were considered to be basic inherent design components that absolutely required implementation while the other two functionalities were considered to be extra features that could still enhance the user-device interaction.

The first of the functionalities considered to be critical to the user experience was the ability to automatically produce a list of available recipes based on the available ingredients that were loaded by the user. As discussed in the previous section, this particular functionality would allow users to filter out all of the recipes that they wouldn't even be able to create in the first place for that occasion. Though I initially believed that solely using the systematic proportioning system was the best way to define recipes, I decided to challenge that idea by asking survey participants if they would actually want to be able to increase or decrease the alcohol content. To my surprise, however, this ability to alter the liquor quantities of any recipe was also considered a critical functionality. Considering that this provides the user with a bit more flexibility and

control of the drink-making process without requiring any intervention, it is reasonable to see why this particular functionality might be attractive to a user.

One of the presented functionalities considered to be more of a nice extra feature than a critical need was that of allowing the user to create and save custom recipes. By implementing this functionality, would be able to test the knowledge he or she is gaining through use of the device and perform quick trial and error taste tests on recipes they think would be successful. Another idea that I chose to pose to the user study participants was being able to scale down recipes to pour even smaller quantities of each recipe so that the user can try out the drink before he or she decides to pour a whole drink. This was generally accepted positively by potential users, so there is a possibility that this type of functionality could play a bigger role in situations where users simply want to taste a variety of cocktails in smaller volumes than consume entire drinks.

4.3 UI Design Overview

Because the device's primary feature is the automatic dispensing of various ingredients to produce specific cocktails, it is critical that the ingredients in a container match what the system thinks is in that container. Because a system of detecting what ingredient is in a container would be too complex and possibly not even feasible, it is important that the user clearly understand what must be done to register each ingredient that is loaded into the device. Figure 18 shows the UI home screen directly linking to the ingredient loading screen; this feature is made immediately available to the user rather than hidden away in a settings menu because it is critical to the performance of the device. The user is presented with a top view graphic of the device that shows a number assignment for each of the containers. By selecting the area over one of the containers, an LED indicator on the physical system should light up indicating which container should have the ingredients poured into it. The user can then press load, select the ingredient and pour into the indicated container.

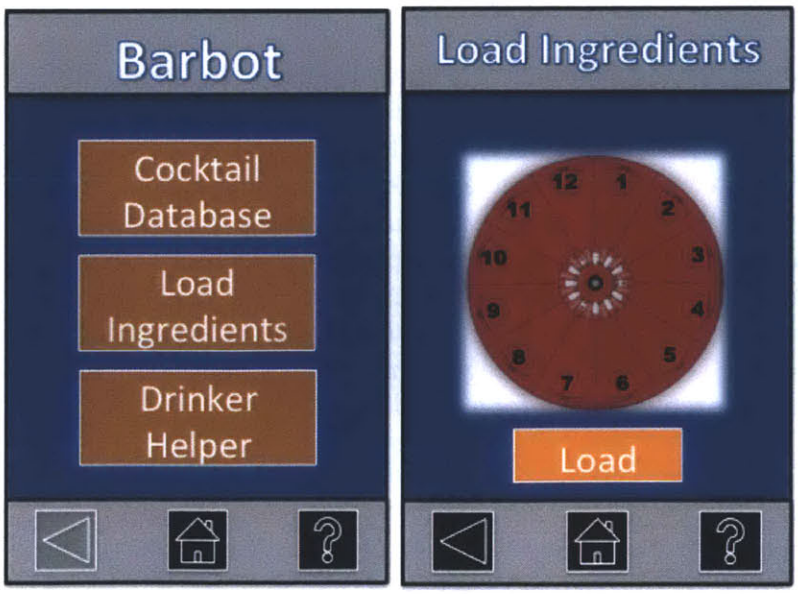


Figure 18: UI main menu (Left) and ingredient loading interface (Right)

Once the user has loaded all ingredients, he or she can then move on to select a recipe from the extensive cocktail database. The options there would be to view the full database to see which recipes are registered with the system or to view the available recipes database that cross references the full database with the loaded ingredients to output all recipes that can be poured at that moment. As shown in Figure 19, the screen for a specific recipe presents each of the ingredients that go into it as well as the respective volumes. This menu gives the user the option to make the drink stronger (more alcohol) or weaker (less alcohol), to their liking. This function, in its current design, increases or decreases volumes all alcoholic ingredients proportionally so as to maintain the flavor of the cocktail as much as possible. The Francois Barbot discussed earlier in this thesis gave users the ability to increase or decrease volumes of each individual ingredient, but that method gives the user too much flexibility to the point that the bartending knowledgebase aspect of the device is no longer present.

Figure 19: Cocktail recipe database and drink ordering interface

The "Drinker Helper" functionality is partly based on the Cocktail Flow digital application that was discussed earlier in this thesis. This particular part of the system is meant to help the user determine what ingredients are needed to make a set of selected drinks or conversely, what drinks can be made from a set of selected ingredients. Figure 20 shows how a user can select any number of recipes from the full database and output a list of ingredients required to make all of those recipes, essentially providing the user with a shopping list. The current system simply produces a qualitative assessment of the required ingredients, but by prompting the user how many of each selected drinks he or she would like to be able to make the system can calculate the volume of each ingredient required; this would be most helpful for a user who is shopping for refreshments for a small party.

Figure 20: Drinker helper recipe selection system and shopping list output

Discussion and Future Development

4.1 Prototyping

Now that the design concept for the automated cocktail mixing device has been more clearly defined, the next step will be to determine what critical questions need to be addressed in order to determine what kind of prototypes should be pursued in future development. The two types of prototypes that should be pursued fall into the categories of mechanical design and user interactivity, where the focus of mechanical design should be to test the functional capabilities of the device and that of user interactivity should be to test how intuitive and easy-to-use the interface is from the perspective of the user.

The mechanical design of the liquid source container and black box module can be split up into to different prototype directions. The first is investigating methods of easily interlocking and removing the container to and from the black box device. In order to promote consistent flow, there is a need for sufficient flow and sealing at the container/black box interface to ensure a resistance to leaking, which is completely dependent on the method used to interlock the components together.

The secondary mechanical design focus is that of the electronically controlled valve system that opens and closes to allow and restrict the flow of liquid ingredients. The two main directions this can go in is that of a solenoid valve that could easily be attached to a tube system leading from the container/black box interface to the cup or a pinch valve that would be composed of an actuator and a spring designed around a tube leading from the interface to the cup. The latter option would pose greater risk because it would be a custom made assembly of a tube cross-section being compressed by a spring with an actuator pulling the spring back to allow flow. Because commercial solenoid valves might be too expensive or produce to low of a flow rate, however, the pinch valve option could be more promising in responding to changing requirements.

A prototype focusing on user interactivity would help determine what changed must be made to the interface to ensure that users clearly understand how they are meant to use the device. The main issue that should be addressed in this regard is the loading of ingredients into the liquid source containers based on prompts from the user interface. This prototype will require the development of a coded interface that is representative of the proposed "Load Ingredients" interface so that users can go through the motions of loading an ingredient and receive appropriate feedback from the device. By arranging 12 containers in a circular pattern and attaching programmed LEDs to each, further testing can be done by observing users loading ingredients using the digital application.

4.2 Conclusion

Throughout the course of this project, the idea for an automated cocktail mixing device was developed into a detailed assessment of various physical design and digital application design considerations to best optimize the user experience. Through research, benchmarking of

various "barbot" devices and a user study, I was able to gain insight into the types of existing functionalities add or detract from the user experience. Through various brainstorming sessions, I came up with a myriad of different functionalities that could improve the user experience. Each of these functionalities, however, added another degree of complexity that could directly affect potential cost of the product and the required steps for operations. By reaching out to potential users and using existing projects as a baseline, I was able to filter out those functionalities that seemed appropriate but didn't really have any added value to the user experience from the point of view of various participants of the user study. These gained insights allowed me to align the development of the automated cocktail mixing device design concept to the best meet the needs of potential users.

If the design concept were to be further developed, more detailed research should be conducting on the intended markets for the device to determine where the most feasible and successful point of entry would be. Further research into these markets could reveal differing customer needs, which would require redesign considerations or a split design into different models.

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