Final Design Report: HydroCatch – The Adjustable Water Catcher for Papermaking

Prepared for

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Submitted by

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Executive Summary

Problem and Client – The Rose Center, a center for adults with disabilities, handmakes paper as one of their favorite activities. During this process, water runs off the table, causing damage to the floor tiling and creating a safety concern. With the help of director Raul Barrera, the HydroCatch was designed.

Purpose and Scope – The purpose of the HydroCatch is to reduce water spillage as a result of the Rose Center's papermaking process.

Methodology – Observation at the Rose Center and interviews with members provided deeper understanding of the main issue. Design reviews were conducted on four mockups, and feedback helped determine the final design concept. Performance testing on the final mockup informed decisions made when building the final prototype.

Figure 1. The HydroCatch

Design Summary – The HydroCatch is an adjustable gutter system with two c-clamps that attach to the table legs, allowing for easy removal. Brackets enable the user to choose the distance between the gutter and table edge, and the middle of the gutter has a flexible hose tube that can stretch to fit any table length. HydroCatch's adjustability and low profile allow the Rose Center to maintain their current, enjoyable paper-making process while staying out of the way of users in wheelchairs and crutches.

Future Development – Future iterations of the HydroCatch should explore augmenting the collapsible portion of the gutter, making it easier for the gutter to attach to the table, and implementing an automatic bucket rotation system.

Introduction

The HydroCatch seeks to address the difficulties the Envision Unlimited Rose Center has been experiencing with their therapeutic papermaking process. The problem revolves around excessive water spillage during the activity. The papermaking process itself is fun and engaging for the members of the Rose Center, but the volume of water that ends up on the floor causes damage to the tiling and presents safety issues (see Appendix A: Project Definition for full user scenario). This water spillage mostly occurs when the newly formed paper is placed between wet towels, which are then compressed, causing water to drip off the sides of the table in large quantities. See Appendix B for further details on paper-making and Appendices C and D for observations on the Rose Center's paper-making process.

Another problem present at the Rose Center is the lack of accessibility within the papermaking process for users of varying ability levels, such as individuals with wheelchairs or hand crutches. The current setup for the papermaking activity makes it such that the users mentioned above cannot safely participate, along with the excessive water spillage. A main goal of the HydroCatch is to ensure that accessibility is not worsened through its addition. The lengthy drying time was an additional problem mentioned, however, other prototypes are being designed to address it.

Currently, the Center uses towels, plastic tarps, and buckets to manage the water spillage. They use the towels to mop up water on the tables and lay the tarp beneath the table to prevent the water from going directly onto the floor, with some buckets placed under the table to catch spills in specific areas. Unfortunately, they have not found these measures very effective as large amounts of water still end up on the tarp and the tiling is still becoming undone. Furthermore, members of the Center with mobility aids are not able to participate due to safety concerns, and they are still considering various adjustments that would allow their involvement.

This report details the way in which the issues were addressed and the design choices that were considered. The report outlines the main users and stakeholders for this design, as well as the requirements that were set for the prototype to achieve. Those sections lead into the design concept and rationale that details the basics of the design and why each part is integral. Finally, there is a reflection on the next steps and future developments the product could take.

Users and Stakeholders

Members of the Rose Center - The members of the Rose Center have a variety of physical and intellectual/developmental disabilities. These include the use of crutches and wheelchairs, loss of fine motor skills, and limitations of mental capabilities. The members also span a wide range of ages and genders. It is impossible to know/predict every challenge that the users face, so the product must be designed in the most accessible way possible.

Staff of the Rose Center - The staff of the Rose Center manage all of the activities, including paper-making. They are often responsible for the set-up of, running of, and cleaning up after these activities. When there are large amounts of water on the floor, it becomes much more difficult to manage the activity in a safe and engaging manner. With fewer disabling challenges, the staff are better suited to implementing a device that may be more difficult if necessary.

Design Requirements

- **Reduces water damage/spillage -** The staff at the Rose Center want to keep their current floor tiling and prefer that a design not alter or interfere with the flooring while also mitigating the water spilled on the floor.
- **Maintain accessibility with respect to the room's space and the table -** The space within the Rose Center is limited and there are members of the Rose Center who use wheelchairs and crutches. Thus, the design must be compact enough to not waste space and be out of the way during the paper-making so as not to be a hindrance to the users or other people in the space.
- **Keep the current paper-making process the same -** The participants at the Rose Center enjoy the current papermaking process, and as such the HydroCatch is designed to not detract from the fun of nor alter the papermaking process.

More information regarding the design requirements are outlined in the project definition in Appendix A.

Design Concept and Rationale

Overview of Design

The idea of a device that could catch the water that ran off the table before it ever hit the floor became a leading choice because of the way it could address all of the users' concerns. No water on the ground would mean no damage to the tiles, a process that remained unchanged, and less safety risks that come with a wet floor. After multiple iterations and feedback from Rose Center director Mr. Barrera, the design for the water catcher was finalized as a gutter system (Appendix D).

The HydroCatch is a gutter system designed to clamp onto a table and catch water as it flows off the sides. It is adjustable length-wise, allowing it to fit onto any sized table, while also adjusting in and out from the edge of the table, giving the client the ability to choose the optimal spot so the gutter catches the water while having a low profile. The gutter is also slanted such that the water can drain down into a bucket on one side (Figure 2).

Figure 2. HydroCatch Gutter

Design Attributes

Gutter

A PVC pipe was halved in order to create two gutter sections capable of retaining water, which are then attached on either side of the flexible hose tube. Each end of the PVC pipe connects to a rectangular piece of metal (Figure 3). This piece of metal has multiple holes drilled into it that allow the pipe to connect to the table

bracket, allowing the gutter to sit at various distances from the table (Figure 4).

Figure 3. PVC adjustability

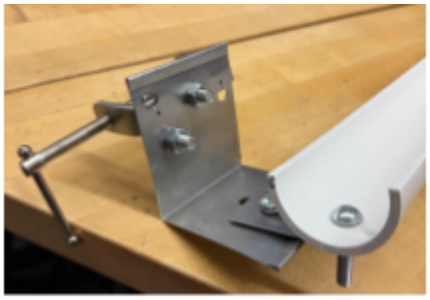

Figure 4. PVC Pipe bracket connection with correct pipe orientation

The other section of the gutter is a flexible hose tube with an accordion-like structure that allows it to lengthen to the user's desired length (Figure 4). The tube itself can vary in length from 9 - 50 inches (Appendix F). The flexible hose tube is the center part of the main gutter and will be attached to a PVC pipe on either side (Figure 2). To prevent water spillage during the crossover from PVC to flexible hose tube, the sections are secured with waterproof duct tape and a strong adhesive glue (Figure 5). See Appendix G for details on specific cost of the various materials used in the design.

Figure 5. Flexible Hose Tube

Figure 6. Flexible Hose Tube connection with PVC pipe

Bracket/Clamp

When designing the bracket, there were concerns about making it both adjustable and strong with a secure connection to the table. Initially, the PVC pipe would be on a rail that could slide out from the bracket, allowing for continuous adjustability. However, the design freeze revealed the difficulty of implementing this, and a simpler design was used. In terms of security and strength, changes to the gutter itself like the half PVC and half flexible hose tube reduce the weight the brackets would have to hold.

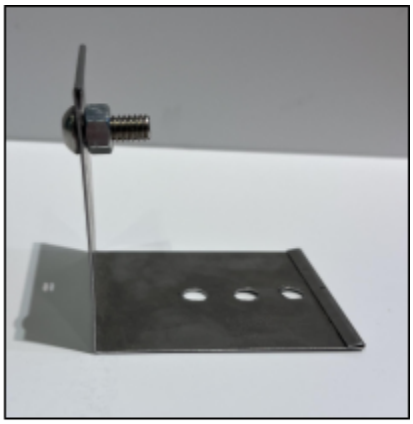

Figure 7. Bracket Side View

The current bracket is made up of a piece of sheet metal bent into an L with the C clamp screwed to the back side (Figure 4). This part attaches to the leg of the table and is not adjustable. On the bottom of the bracket are multiple holes for the PVC pipe to attach to. This allows the gutter to be closer or farther from the table leg while still securely connecting to the bracket and provides 2.75 inches of adjustability. This system holds the weight of the gutter and water without failing. Additionally, the C-clamp rests on an added bolt on the back of the bracket and holds the PVC pipe at an angle ensuring proper water flow (Figure 4).

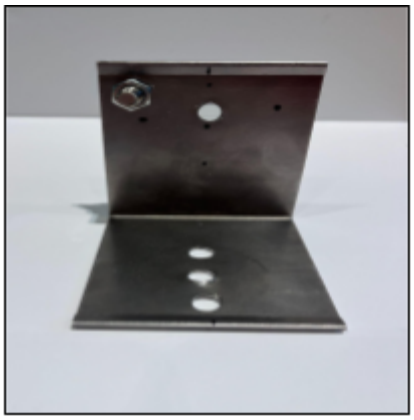

Figure 8. Bracket Front View

How the design addresses our requirements

The two forms of adjustability allow the HydroCatch to meet two of our design requirements: maintaining accessibility and reducing water damage. By moving where the PVC pipe attaches to the clamp, the gutter can be placed at the exact spot under the table edge where the water drips the most, preventing water from reaching the floor. Performance testing demonstrated that up to 96% of water was successfully redirected by the gutter and prevented from reaching the floor. With little to no water on the floor, the space is accessible to those in wheelchairs and crutches. The way the C clamp allows the HydroCatch to connect under the table allows it to meet our final design requirement, keeping the overall paper-making process the same. The gutter system can be implemented with no other changes to the process. Additionally, the diameter of the PVC pipe section is small enough (2.5’’) that it won’t obstruct the participants while they are engaging in papermaking. See Appendix G for instructions to build the gutter and Appendix H for more details on instructions for use.

Overall, the HydroCatch is a solution that maintains accessibility, safety, and the current process the members of the Rose Center enjoy.

Next Steps and Future Development

Alternative Designs

There are three alternative designs/additions that were considered.

- A future design for the collapsible aspect of the gutter would have each segment clip together like puzzle or LEGO pieces. Attachments would be 3D printed and screwed underneath the gutter so that as many or as little gutter sections could be used depending on the length of the table. This would allow for increased adjustability, reduced flex throughout the design, smoother water flow, and easier storage.

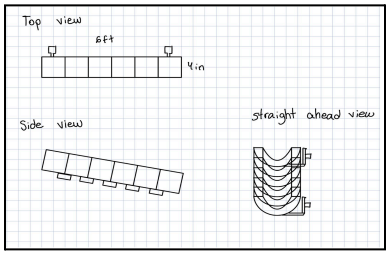

Figure 9. Future Prototype Design

- A future design could include an easier, more accessible way for users to fasten the gutter to the legs of a table with electronics or other means to automate the process and make it easier. This would involve the members of the Rose Center in the set up and take down of the activity, as well as helping with fine motor skills.
- Another future design could implement a more advanced bucket rotation system, making it easier for users to switch out buckets as they fill up with water. This would mitigate the risk of forgetting about the bucket becoming full and having it overflow.

Further Testing

While much testing was done (see Appendix E), it was not possible to properly test how the gutter would maintain its structural integrity over time due to time constraints. Further testing in this area would include:

- Testing how the water affects the material and connections of the gutter over long periods of time
- Testing if the clamps lose their strength over time

New Materials

Based on the further tests listed above, these are the areas that could use different kinds of materials

- The flexible tubing
- The connection point between the PVC pipe and flexible tubing
- The clamps

Conclusion

In summary, the HydroCatch offers a sleek, usable, and effective solution to the water spillage issue at the Rose Center that meets the users' requirements. The users desire limited changes to the papermaking process in addition to wanting any additions to the space to not hinder accessibility for people in wheelchairs or individuals who would rather sit as they work. In addition to this, the Rose Center wants a design that could scale with the table and would make clean-up faster. The HydroCatch accounts for these considerations through its collapsible gutter which attaches to the table using clamps, giving the design a wide range of application across various table heights and lengths. As the design would funnel water directly into the buckets, this design also greatly reduces the mess created by the papermaking process and thus reduces the time required to clean the workspace. Performance testing demonstrates that the HydroCatch offers upwards of 90% effectiveness at mitigating water spillage when appropriately attached to and configured for the table (Appendix F). All in all, the HydroCatch's collapsible and easy to set up nature makes it a modular and effective solution to the Rose Center's water spillage issue, which will reduce water damage to the floor tiling and make the papermaking environment safer and easier to use while not detracting from the fun and therapeutic aspects of the activity.

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Jamie Thome, Hive Center for the Book Arts - paper making expert
Mr. Barrera - Rose Center program director

Secondary

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APPENDICES

APPENDIX A: Project Definition

Project Name: Improved Paper-making Process

Project Partner: Raul Barrera, Envision Unlimited

Team Members: Gus Goyal, Tolu Adeyefa, Olivia Bakke, Matthew Knigin

Date: November 3, 2025

Version: 3.0

Mission Statement: Design a table attachment that significantly reduces the volume of water spilled onto the floor, provides a sustainable way to reuse that water, and ensures a safer and cleaner work environment.

Project Deliverables:

- Final Report
- Prototype
- Final Design/Product

Design Constraints:

- Keep the general paper-making process the same
- Keep current flooring
- Maintain accessibility with respect to the room's space and the table

Users and Stakeholders:

- Members of the Rose Center – the individuals adults ages 20 to 50 with developmental or intellectual disabilities that are participating in the papermaking activity
- Staff of the Rose Center – the individuals who run and maintain the activities and facilities

User Profile:

- Adults with intellectual and/or developmental disabilities. Users span a range of ages and genders. Their various disabilities contribute to some

challenges in the papermaking process, but the larger issue is their ability to manage the large volumes of water being spilled throughout the activity.

Illustrative User Scenario:

- The members of the Rose Center make homemade paper as one of their activities. It is an engaging and therapeutic activity, but there are some problems that arise with the volume of water that ends up on the floor, the drying time, and accessibility. During the process, the drenched towels and paper mean that large quantities of water are dripping onto the floor, causing the tiling to come undone

Project Requirements - Needs, Metrics, and Specifications:

Table 1. Project Requirements

Needs	**Metrics**	**Units**	**Ideal Value**	**Allowable Value**	**As Built**
Easily attachable to the longer sides of the table without obstructing the users during the activity	Max Length	ft	6 Based on how the current table is built	6.5 Current length of table accommodating for solution attachments	To be updated once the prototype is built.
	Max Height	in	3 To maintain accessibility and access to table functions	7 Largest height without becoming a hindrance to the process	To be updated once the prototype is built.
	Max Width	in	4 To maintain accessibility and access to table functions	6 Most that the gutter could protrude without inhibiting others	To be updated once the prototype is built.
Clamps hold gutter weight and	Weight	lbs	3 times gutters own weight to	1.5 times gutters own weight	To be updated once the

weight of water			account for water		prototype is built.
Adjustability	length	in	12 inches of length adjustability, 4 inches of width	4 inches of length adjustability, 2 inches width	To be updated once the prototype is built.

APPENDIX B: Secondary Research Summary

The paper-making process has remained largely unchanged since the first paper came about in China. The general process of creating pulp, setting it, and drying it to create paper remained the same as it went to Korea, Japan, Egypt, and eventually Europe [16]. Eventually, machines and paper mills were developed to make paper faster and automate parts of the process, but handmade paper was still popular. Today, paper is still made with pulp, which is often derived from shredding up older paper and cardboard. The paper mixture is ripped, soaked in water, and then formed into pulp with a blender. The pulp can be placed into a bowl and then set onto a screen to dry [20]. The paper-making process requires water, and throughout the process, spills are likely to occur. Spills, especially in industrial settings, can lead to lost profits and inventory. There are numerous ways to prevent and mitigate spills. Preemptively checking and insulating pipes, roofs, and foundations are ways to prevent leaks before they happen [3]. After spills occur, however, there are methods and devices that make clean-up and containment efficient. Absorbent materials are one option, and absorb large amounts of water relative to their weight. The absorbent polymers can take the shape of fabrics that absorb spills to booms that contain them [11]. Booms and socks don't have to be made from these absorbent materials and can just be used to contain spills and stop their spread [3].

The papermaking process is a highly variable process depending on the circumstances under which it is made. In industrial settings, the papermaking process generally adheres to the following steps: prepare the paper stock, form the paper, press the paper to remove moisture, dry the paper further (often utilizing multicylinder dryers or Yankee dryers), calender the paper, and finally reel the paper [16]. This process is considerably more mechanical than the comparatively manual process of at-home papermaking. There is an alternative more human-centric, manual approach to making paper, in which the papermaker soaks old or recycled pieces of paper in a bowl of water until the paper has become sufficiently soft and ready to be blended before blending the paper until it has become a moist, gray paste [14]. After the blending is done, the paper paste is poured into a mold where it is then padded using towels to remove excess moisture before being left to dry for an extended period of time. While these two methods vary greatly in terms of mechanization, they both lead to the same end result of making paper.

Another particularly important facet of researching the papermaking process was gathering information on methods and techniques of drying paper, so as to be more time efficient. Bannister details several techniques used to dry paper during the manufacturing process including applying pressure with weights,

sticking the paper on walls, and placing the paper on heated metal sheets [2]. Meanwhile, one source demonstrates how one could press towels on paper while it's in the mold to absorb excess moisture and thus expedite the drying process [14]. Goedvriend [7] and Bannister [2] go into greater detail on how industrial paper plants dry their paper using an assortment of devices. Two such devices are foils and suction boxes, which remove excess water from the paper mixture prior to starting the actual drying process. After these devices have been used, steam heated cylinders are used for more efficient drying. According to Hiziroglu [10] and Poirier et al. [16], there are alternative methods or variations to the steam-heated cylinders used to dry paper, including drum dryers, multicylinder dryers, and Yankee dryers, which all apply heat and pressure to the paper in order to remove moisture. According to Poirier et al. [16], drum dryers differ from the multicylinder and yankee dryers in that they push heated air at the paper in order to dry it and thus do not utilize the same quantity of pressure as the other types of dryers.

Another aspect of the papermaking process that is worth mentioning is the impact of using recycled paper when making new paper. Goedvriend [7] asserts that recycled fibers from the original paper can be left in the new paper as debris and thus slow water drainage and the drying process as a whole. The industrial answer to this issue has been to rely on polyelectrolytes to curtail the impacts of the debris. Another manner of confronting this issue is called deinking by flotation, which has been shown to remove a large proportion of fillers and fiber debris within recycled paper.

Intellectual and Developmental Disabilities (IDD), in short, are disabilities that present themselves in early childhood and develop into adulthood. They can be caused by a number of different factors, such as gene mutations, abnormalities with pregnancy, or even things that scientists have yet to discover[5] . There are four main development areas that can be affected: motor (gross and fine), language, social, and intellectual[5] . A motor delay, or a delay in a child's physical milestones, often can be an indicator of Cerebral Palsy. Slow progress in the language or social areas (when limited to specifically those two areas only) is usually a sign of Asperger's Syndrome. Finally, intellectual disabilities can be determined by a person's Intellectual Quotient (IQ), with any number below 70 being considered out of the 'normal' range. Common conditions causing mental impairments are Fragile X Syndrome, Down Syndrome, and Fetal Alcohol Syndrome[5] . There are also other areas that can be affected by developmental disabilities, such as hearing or vision.

Concerning specific Intellectual Disabilities, there are four categories of severity: mild, moderate, severe, and profound[3]. The majority fall under mild or moderate, meaning that the person has some sort of independence, without needing full-time support from someone. Severe requires more aid, while those in the profound category need full-time supervision and care[3]. All of this information is clearly labeled in Table 3 below.

Table 2. Intellectual Disability Severities

Severity Category	Approximate Percent Distribution of Cases by Severity	DSM-IV Criteria (severity levels were based only on IQ categories)	DSM-5 Criteria (severity classified on the basis of daily skills)	AAIDD Criteria (severity classified on the basis of intensity of support needed)
Mild	85%	Approximate IQ range 50–69	Can live independently with minimum levels of support.	Intermittent support needed during transitions or periods of uncertainty.
Moderate	10%	Approximate IQ range 36–49	Independent living may be achieved with moderate levels of support, such as those available in group homes.	Limited support needed in daily situations.
Severe	3.5%	Approximate IQ range 20–35	Requires daily assistance with self-care activities and safety supervision.	Extensive support needed for daily activities.
Profound	1.5%	IQ <20	Requires 24-hour care.	Pervasive support needed for every aspect of daily routines.

From: 9. Clinical Characteristics of Intellectual Disabilities

There are a lot of motor functions that can be affected in people with IDD. In a study done on children with various forms of IDD under the age of six, results showed that certain IDDs scored higher on fine motor skills than others[12]. The children had to perform various tasks such as picking up coins, drawing, and threading beads. It was found that children with Asperger's Syndrome scored well, while other children with intellectual disabilities struggled more[12]. Children with Attention Deficit Hyperactivity Disorder also scored highly. From this data, it can be seen how fine motor skills are connected to cognitive development[12].

Table 3. Abilities within Disabilities

Tests	Group 1							
	ASD (*N* = 275)	ID (*N* = 124)	ADHD (*N* = 234)	Comorbidity[a] (*N* = 212)	Motor dysfunction (*N* = 109)	Unspecified DD (*N* = 418)	TD (*N* = 52)	F
MABC-2								
Placing coins	7.8 (2.7)	5.1 (3.1)	8.1 (3.1)	5.9 (3.2)	6.5 (3.1)	8.5 (2.9)	9.4 (2.1)	40.8***
Threading beads	7.7 (2.9)	5.0 (3.1)	8.1 (3.0)	5.5 (3.2)	6.2 (3.1)	8.4 (3.0)	10.1 (2.4)	48.1***
Drawing trail	7.3 (3.9)	3.3 (3.2)	7.8 (3.6)	4.6 (3.8)	5.3 (3.9)	8.0 (3.8)	8.8 (3.0)	48.2***
Manual dexterity	7.4 (2.7)	4.1 (2.4)	7.9 (2.9)	5.1 (2.7)	5.6 (2.7)	8.3 (3.1)	9.7 (1.9)	73.1***
	Group 2							
	ASD (*N* = 88)	ID (*N* = 99)	Comorbidity (*N* = 73)	Motor dysfunction (*N* = 19)	Unspecified DD (*N* = 172)	TD (*N* = 22)	F	
PDMS-2								
Grasping	8.6 (1.2)	7.4 (2.2)	8.1 (1.5)	6.8 (1.9)	8.8 (1.4)	9.0 (1.0)	15.2***	
VMI	7.5 (1.6)	5.7 (1.4)	5.3 (1.6)	5.6 (1.2)	8.4 (1.9)	9.6 (1.4)	65.2***	
FMQ	88.5 (6.1)	79.8 (8.9)	80.1 (7.0)	77.4 (5.0)	91.2 (9.7)	96.1 (5.7)	43.8***	

Placing coins: TD = unspecified DD*>ADHD = ASD**>motor dysfunction = comorbidity = ID.
Threading beads: TD **>unspecified DD = ADHD *>ASD ***>motor dysfunction = comorbidity = ID.
Drawing trail: TD = unspecified DD = ADHD = ASD ***>motor dysfunction = comorbidity = ID.
Manual dexterity: TD = unspecified DD **>ADHD = ASD ***>motor dysfunction = comorbidity = ID.
Grasping: TD = unspecified DD = ASD = comorbidity ***>ID = motor dysfunction.
VMI: TD = unspecified DD***>ASD***>ID = motor dysfunction = comorbidity.
FMQ: TD = unspecified DD**>ASD***>comorbidity = ID = motor dysfunction.
[a]Comorbidity includes: ASD + ID (*N* = 98), ASD + ADHD (*N* = 72), ID + ADHD (*N* = 25), ASD + ID + ADHD (*N* = 17); PDMS-2, Peabody Developmental Motor Scales-Second Edition; VMI, visual motor integration; FMQ, fine motor quotient.
***$p < 0.001$

From Comparing fine motor performance among young children with autism spectrum disorder, intellectual disability, attention-deficit/hyperactivity disorder, and specific developmental disorder of motor function

As children with IDD age and turn into adults with IDD, these motor and cognitive impairments stay with them, meaning that even as adults they can need help with what are referred to as “activities of daily living” or “instrumental activities of daily living"[17].

Activities of daily living

- Bathing
- Getting dressed
- Using the restroom
- Assistance with sitting/lying down
- Needing assistance moving around the house

Instrumental activities of daily living

- Cooking meals
- Shopping
- Paying bills
- Making calls
- Doing laundry

A study was done where adults with IDD (or their caretakers) were asked which of these activities they need assistance with on a daily basis, and their responses and particular impairments were recorded[18]. The study found that for people with more concentrated disabilities, such as blindness, deafness, and epilepsy, there were often only one or even zero activities where they required help, while adults with Cerebral Palsy had the highest proportion of needing support in all areas. It was also found that adults with more than one disability had a much higher percentage of requiring assistance, especially in two or more categories, and had an even higher percentage if one of those disabilities included an Intellectual Disability[18]. It is important to note, though, that within this study there was only one percentage that actually hit one hundred percent, meaning that not all adults with IDDs are completely helpless, and many value their own independence and thus work very hard to be able to do as many of these activities by themselves[18].

Finally, mental affects must be considered along with any physical or intellectual impairments. There are three main struggles in children with disabilities that go beyond just the physical challenges. Firstly, in special needs children, the rate of rejection from other students rises drastically from the norm, due to not being able to socialize in a physical way, such as playing active games[15]. Secondly, the concern of internalized anger and frustration arises. Being coddled, seen as different from other children, or not being able to release energy in a physical way can cause a buildup of emotions that could burst at any moment[15]. Finally, many children with disabilities are not just rejected but treated in unkind ways just due to how they look[15]. These three challenges faced by children with disabilities are important to remember, especially when we think that they only face physical ones.

A study by Kim and Chung found that given this generation's new affinity to smartphones and social media, the teenagers with disabilities have an increased sense of autonomy [11]. Additionally, digital art therapy was found to have made it easier for people with intellectual disabilities that affect their verbal communication [11]. In all, art therapy has turned into an important experience that improves the ability of adolescents with intellectual disabilities to express themselves and communicate effectively. It was found that art therapy provides opportunities for increased curiosity and enjoyment of creative activities [11]. Not only can digital art therapy be effective, but standard art therapy can also contribute to the social, emotional, and academic adjustment in children with learning disabilities. Freilich and Shechtman's study investigates the contribution of art therapy to children who have learning disabilities and assesses the outcomes [6]. The results showed that more favorable outcomes appeared in an adjustment under art therapy and that there was similar progress in academic achievement no

matter the condition [6]. The academic intervention focused on improved learning experiences, while the art therapy intervention focused on emotional exploration and awareness-insight development [6].

Art therapy can also be influential for individuals with specific intellectual and developmental disabilities (IDD) such as autism and attention deficit hyperactivity disorder (ADHD). Typically, an individual with autism will have certain learning disabilities that affect their communication skills and emotional regulation [19]. Wright's study is a six-week art therapy program for an adult with autism, as well as a learning disability, anxiety, and a sensory processing disorder [19]. The researchers wanted to find out if art therapy could be an effective approach to help them develop their communication and emotional regulation abilities. Similarly, a study conducted by Habib and Ali aimed to look at the efficacy of art therapy in combating the symptoms of Attention Deficit/Hyperactivity Disorder (ADHD) in children [8]. There are many symptoms of ADHD that manifest behaviorally such as drifting off task, having failure or difficulty in maintaining focus, being disorganized, etc [8]. These symptoms are thought to be linked to different underlying cognitive processes [8]. The results found many benefits to art therapy: (1) it's appropriate for a child to participate in, (2) it uses visual learning skills, (3) it provides a sense of structure for the child, and (4) it allows the children to express themselves freely [8]. Wright's study came to related conclusions that more research regarding art therapy and individuals with autism needs to be conducted, as well as the overall reasoning that art therapy can help a person understand and manage their emotions [19].

Now, more than ever, there is a larger emphasis being placed on integrating people with intellectual disabilities (ID) into communities to improve their quality of life. Past research has shown that people with ID can engage in specific psychodynamic activities such as art therapy that enables non-verbal expression and communication of conscious and unconscious mental content through art materials [9]. Harpazi et. al's study focused on the perceptions of art therapists who work with adults with ID to understand the smaller components of their therapeutic work, seeing which parts help the individual [9]. The researchers concluded that art therapy for adults with ID should be catered specifically to the needs of the client, paying special attention to them while also considering outside factors that might impact the therapeutic process [9].

APPENDIX C: Observations Summary

Introduction

At around 1pm on Thursday, October 2, we visited Envision Unlimited Rose Center and observed the hand-made paper-making process. This observation gave the class first-hand experience with the paper making process, and a clearer understanding of where and why water spills were occurring, and how they impacted the activity and users.

Methodology

To gather information, we observed two members of the Rose Center for approximately two hours as they progressed through the paper-making process within the Rose Center's paper-making room. During this time, the observation group took pictures, videos, notes, and measurements of the workspace and activities. In addition to this, the observation team gathered qualitative data by asking the users and the project partner about their paper-making experience and what irritated them about it and what they enjoyed about it.

Results

During the observation, we saw exactly where water spills occurred. The users set their newly formed paper onto a felt sheet that's on a soaked bath towel. This bath towel is on the same table the rest of the activity occurs on, and is where the greatest quantity of water spillage originates. More water is spilled as the users place and press wet paper on top of felt sheets layered on top of the towel. This process continues until all of the wet paper has been placed on top of felt sheets on top of the towel, at which point an additional felt sheet is placed on top of the paper. Then another soaked towel is placed on top of the felt sheet before a square plastic pane is placed on top of the towel. After this, several cement blocks weighing approximately ten pounds each are placed on top of the glass pane. The greatest amount of water spillage was observed at this point. Regrettably, the observation group had to depart before we could observe more of the drying process. The director of the program, Raul, says the towels are necessary to maintain the structure of the paper before it starts to dry.

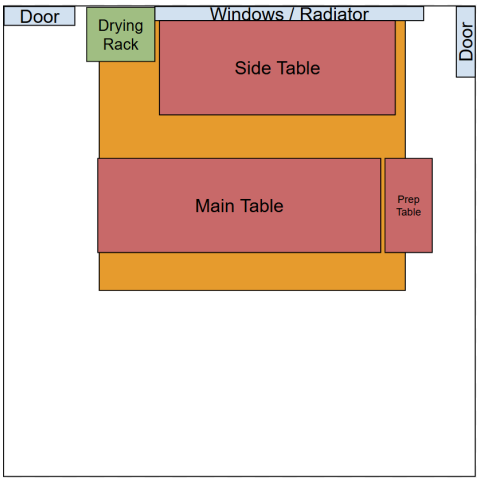

Figure C.1. Envision Unlimited Rose Center Floor Plan

Pain Points

- The room's layout forces users to transfer wet towels from the side table to the main table during the papermaking process.
- This movement of wet materials leads to significant water spillage on the floor, creating safety and cleanliness issues.

Opportunities

- Design a cart to safely transport wet towels between tables without dripping.
- Rearrange the tables so that wet materials can be transferred with minimal distance.

Figure C.2. Work Station at Beginning of Paper-making

Pain points

- The process is very manual with users having to break down pulp and pieces of old paper by hand.
- There is nothing on the table to catch and absorb water that could be spilled during the pulping process.

Opportunities

- Create a device to make the pulping process faster and easier for users.
- Add towels to the table around and underneath the bucket to absorb any spilled water.

Figure C.3. Pulp Submerged in Water

Pain points

- The process is very manual with users having to break down pulp and pieces of old paper by hand.
- There is nothing on the table to catch and absorb water that could be spilled during the pulping process.

Opportunities

- Create a device to make the pulping process faster and easier for users.
- Add towels to the table around and underneath the bucket to absorb any spilled water.

Figure C.4. Pulp Scooped into Shaper

Pain points

- Sometimes the paper doesn't sit perfectly in the mold, requiring users to abandon their current attempt and try again.
- There is nothing on the table to catch and absorb water that could be spilled during the pulping process.

Opportunities

- Create a better mold that makes scooping up pulp easier for users.
- Create a device that minces pulp up into smaller chunks.
- Add towels to the table around and underneath the bucket to absorb any spilled water.

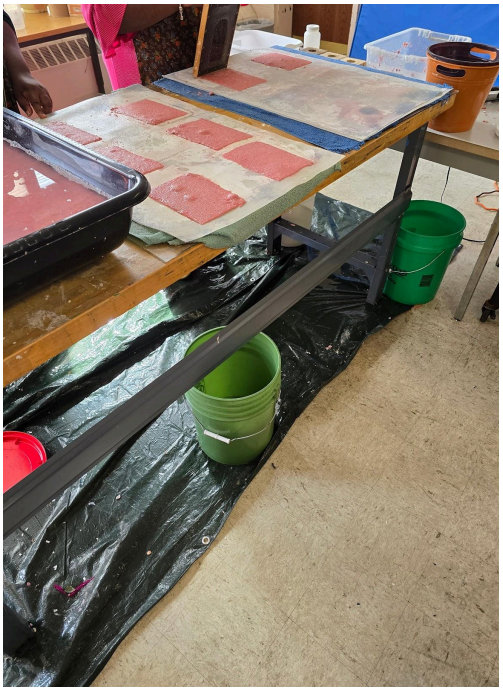

Figure C.5. Paper Placed on Felt Sheets

Pain points

- Due to the wet towels and moist pulp sheets, water accumulates on and slides off the edge of the table in great quantities during this stage.
- Buckets do not effectively catch all of the water, leading to it falling on the floor and on the tarp.

Opportunity

- Create a gutter system that could wrap around a side of the table and catch any water that falls off the side.

Pain points

- This part of the process is highly manual and could be physically inaccessible for people who do not possess adequate strength to lift the blocks.
- This part of the process is highly time consuming and not very engaging.

Opportunities

- Make an easier to use and more engaging way of drying out the paper.

Figure C.6. Cement Blocks Stacked on Paper

Figure C.7. Cement Blocks Stacked on Both Paper Stacks

Pain points

- This part of the process is highly manual and could be physically inaccessible for people who do not possess adequate strength to lift the blocks.
- This part of the process is highly time consuming and not very engaging.
- This process causes great quantities of water to spill off a greater area of the table.

Opportunities

- Make an easier to use and more engaging way of drying out the paper.
- Create a long gutter system that could catch spilled water along the length of the table.

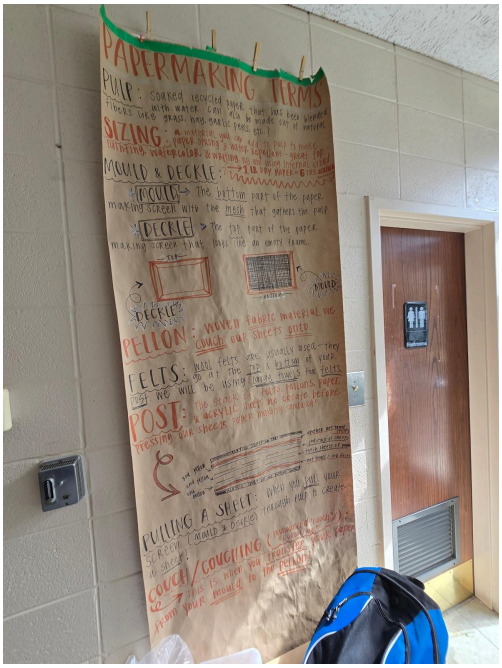

Figure C.8. Poster that Defines Various Papermaking Terms

This is a poster that defines several key terms and steps of the papermaking process. It is useful as a reference and reminder during the process.

Figure C.9. Buckets and Tarp Used for Collecting Spilled Water

Pain point

- The buckets are unable to catch all of the water spilling off the side of the table, leading to water spilling on the tiles and tarp, creating an unsafe environment.

Opportunity

- Create a gutter system that directly routes water to the buckets, leading to a significant reduction in water spillage.

Discussion

A possible solution should address the issue of the towel dripping onto the floor. One option is catching the water before it hits the floor using some type of gutter/bucket system. The process itself can also be changed so that the towel isn't necessary, or is placed on some table/device that catches the water. Additionally, potential methods to expedite the drying process could include applying additional pressure on the paper while it is on the table, installing a more efficient fan system to expedite the air drying process, or utilizing heat applied by the sun or electric means to increase the rate of evaporation.

APPENDIX D: Interviews Summary

Introduction

On September 23, 2025, the team interviewed Raul Barrera, from Envision Unlimited's Rose Center as well as his associate Anna over Zoom in order to learn more about the papermaking process at Envision Unlimited's Rose Center and the issues they have been facing regarding the paper-drying process.

Summary of Process

The Rose Center's process for papermaking is as follows:

- Shred old paper
- Place the paper in a bowl,
- Fill the bowl with water,
- Keep the paper submerged for an amount of time,
- Use a hand mixer to blend the paper,
- Pour the paper-water mixture into frames,
- Embed seeds into the mixture and shake water off of the frame,
- Transfer the paper onto soaked felt sheets and clear plastic,
- Stack cement blocks on top of the paper overnight,
- And then move the paper frames outside to air-dry for anywhere from three hours to a day.

Overview of process

The primary issue facing the organization with respect to this process is that, during the drying process and when moving the paper, excess water spills onto the floor tiles, resulting in tile degradation. They are hoping to find a better way to get water from the hose area into the baths and a better overnight drying process. To combat this problem, the center is currently using tarps, mop buckets, and towels to catch excess water and keep it off the floors, to limited success. The client prefers that the overall papermaking process remain the same, and the solution simply complements it and reduces spills. Some limitations for designing are that people in wheelchairs and using hand crutches have an accessibility disadvantage. Also, not everyone is capable of carrying the cement blocks/bricks because currently they are required to pick them up from the floor and place them on the

table. More issues that would be helpful to fix is the idle time spent waiting for the paper to dry, as well as a way to continue the activity in the winter when the paper can't be dried outside because the patio is not covered.

The papermakers at the Rose Center value the process more than the final product. This is due to the transformative and therapeutic aspects of the papermaking process, which help participants heal from and move past traumatic experiences.

APPENDIX E: User Feedback and Testing Summary

Introduction

On October 19, 2025 and October 20, 2025, Team Southpaw met in the Ford Design Center to test mockup ideas in order to observe how effective they were at achieving their goals. The presentation with Mr. Barrera on Saturday October 25 provided the team with additional feedback and guidance for how to move forward.

Methodology

Mock-up 1: Portable Water Catcher

To test the portable water catcher design, we set up the mockup as shown in Figure 1, with the water catcher protruding from the edge of the table by a small margin and with a water receptacle underneath the drainage hole. After everything was set up, we poured water from a water bottle onto the edge of the table so that it would drip off the table's edge in a fashion similar to what was observed at the Rose Center. To determine the viability of this design, we measured how much water spilled outside of the water receptacle.

Figure E.1. Portable Water Catcher View 1

Figure E.2. Portable Water Catcher View 2

Mock-up 2: Water Roller

To test the mockup roller, we created a to-scale model of the table, roller, and person in a wheelchair. This allowed us to visualize how the device could increase accessibility for those in wheelchairs and if the roller would even be feasible. As seen in Figure 4, the model shows that someone in a wheelchair would be able to effectively use this design.

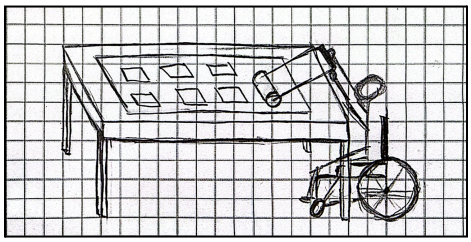

Figure E.3. Water Roller Sketch

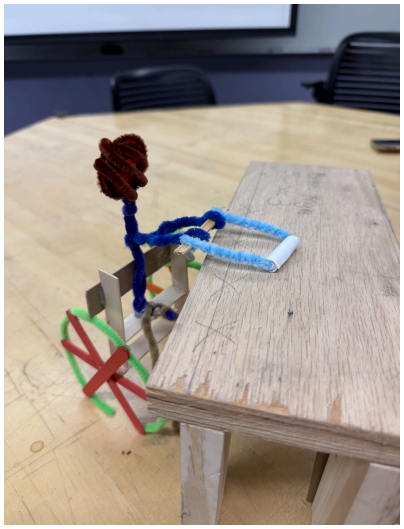

Figure E.4. Water Roller Mockup

Mock-up 3: Detachable Gutter

In order to test the Detachable Gutter, we attached the design to a small to-scale mockup of the table used at the Rose Center. With this, we were able to test and see that the attaching and detaching mechanism worked. The mechanism works by screwing in the screws so that they squeeze the table legs, allowing the Detachable Gutter to stay on the side of the table without needing to be held up. Then, we poured water onto the table and observed how/if the gutter was able to catch the water. We found that the gutter could successfully catch the water. The gutter is also attached to the table at an angle, meaning that the water can flow into a bucket at one end of the table.

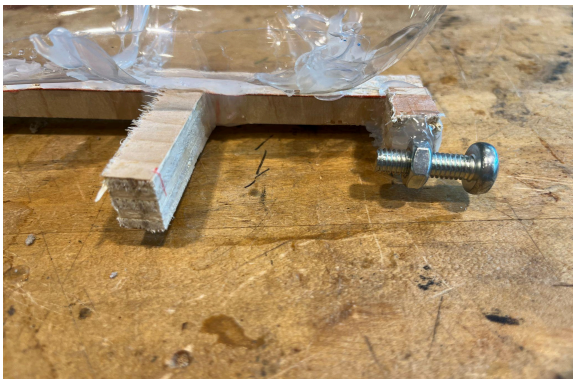

Figure E.5. Detachable Gutter Clamp Mechanism Mockup

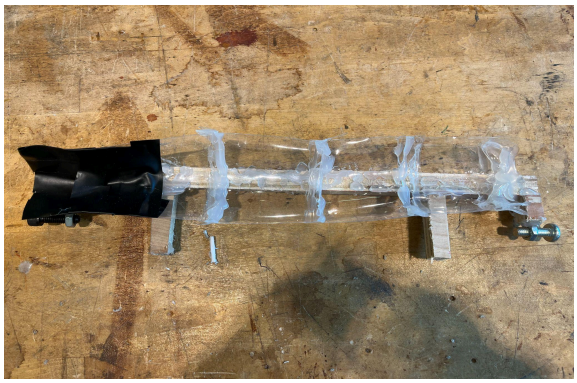

Figure E.6. Detachable Gutter

Mock-up 4: Paper Drying Box

To test the Paper Drying Box, we designed a scaled down box with fans attached to the sides of the box for convective mixing that would dry the paper faster. Inside the box are horizontal racks that would hold the sets of paper as they are drying. In order to make accessing the racks more convenient, the box would open and close on the side. Additionally, underneath the box is a drip pan that would collect the residual water as the papers are drying, and the pan can be detached for easy disposal.

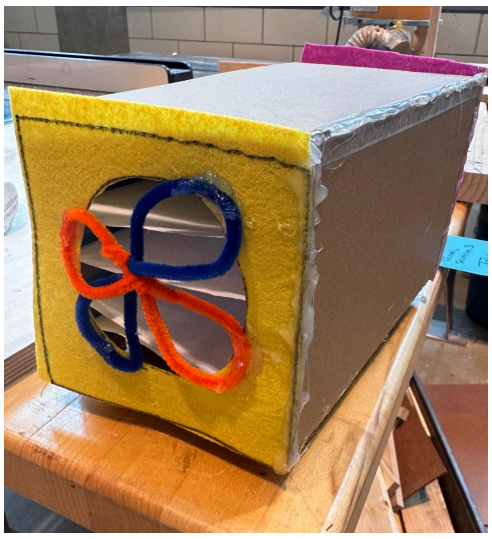

Figure E.7. Closed Paper Drying Box Mockup

Figure E.8. Open Drying Box Mockup

Results: should include images of the mockups during testing, and a description of what you observed and what you measured. Avoid making interpretations here. For example, rather than say "the users found it awkward to use," describe what you saw that led to that conclusion (e.g., it took two tries to make it work, or they had to really twist their arm to use it, or they scowled a bit when using it).

Results

Mock-up 1: Portable Water Catcher

Figure E.9. Portable Water Catcher Testing 1

Figure E.10. Portable Water Catcher Testing 2

During testing, it was observed that when the portable water catcher was properly positioned beneath the table (protruding about 1 inch from the edge of the table) 100% of the water spilled on the table that went over the side where the water catcher was deployed was successfully caught and funneled into the wooden water receptacle, permitted that the water receptacle was properly aligned with the drainage hole. As the majority of the water spillage that takes place at the Rose Center is concentrated on the sides of the table where this design could aptly be deployed, this concept shows immense potential toward solving this issue. When presented to Mr. Barrera, he appreciated the efficiency of the design, but had reservations regarding the design's protuberance from the table and how that could potentially become an issue for people in wheelchairs or people who would like to sit down while they make paper. Additionally, it lacked the functionality to

adjust its height to better adapt to the table. For this reason, Mr. Barrera was more partial to our other gutter-inspired mockup.

Mock-up 2: Water Roller

While the idea of the roller showed promise, points were brought up by the class and Mr. Barrera that need to be considered. One is the weight of the roller. It should be heavy enough to press the water out, but light enough that it can be easily rolled. A possible way to address this is to make the roller smaller so the weight is concentrated onto one piece of paper. Another was that the roller might comprise the integrity of the paper if done too early. Mr. Barrera thought that the device could be used a day or two after the drying process begins, and could be a good way to keep the process interactive after the main paper making ends.

Mock-up 3: Detachable Gutter

During testing, it was found that all of the water that fell off the table was caught by the gutter. The feedback given was generally positive for this mockup. Mr. Barrera highlighted the benefits of the product being adjustable and out of the way, meaning it would not be a hindrance to the members during the paper-making process. This also allows the center to use the tables and chairs throughout the week without having to deal with the gutter still being on the table.

Figure E.11. Detachable Gutter Testing 1

Figure E.12. Detachable Gutter Testing 2

Mock-up 4: Paper Drying Box

Once the idea of the drying box was presented, Mr. Barrera noted the new idea of using fans as a method to dry the paper. Due to the fact that the mock-up needs to be fully tested at the center with the paper, not many comments about the drying box came up after the first impression.

Discussion

Overall, Mr. Barerra's feedback provided us with a direction to continue developing in. The concept of the portable water catcher shows promise, but there are improvements that need to be made before it can be implemented at the Rose Center. The design is highly efficient at reducing water spillage, but needs to become more modular and less of a barrier to people working in that space. Additionally, making sure that water is funneled directly into the bucket by making it easier to align with the drainage hole would increase ease of use. However, the detachable gutter seemed to already contain many of these needed features, with the design's ability to be removed when not in use and it being very out of the way during the process. Certain parts, such as the length the gutter is away from the table, will need to be made adjustable. This is the design that we are going to go more in depth with currently. For the Water Roller, Mr. Barrera liked this design and appreciated that it could be added seamlessly to the current process, increase accessibility and who could participate, and possibly decrease drying time. Regarding the Paper Drying Box, Mr. Barrera found using fans as a drying method an interesting new approach that would help with reducing the drying time.

APPENDIX F: Performance Testing

Test 1. Water runoff from the towel goes into the gutter

Performance testing showed that a wet towel draped off the edge of the table would drip into a correctly placed gutter.

Figure F.1. Water Drips from Towel and Lands in the Gutter

Table 4. Test 2 – How Much Water is Caught by the Gutter

Trial #	Water Poured (fl. oz)	Water Retained in Bucket (fl. oz)	Percentage of Water Collected (%) (fl. oz)
1	24	22	92
2	24	23	96
3	24	23	96

In this test, we observed how much water was captured and successfully redirected by the gutter. To do this, we utilized a 24 fluid ounce water bottle and poured its contents into the left side of the gutter (the left PVC pipe) and recorded how much water was captured by the bucket. We found that a small amount of water became stuck in the hose tube as it flowed through the gutter, potentially altering future trials. This could also explain why the percent of water collected in the first trial is less than the second and third trials, as the team did not dry off the gutter, meaning that water had already pooled in the cracks of the flexible tubing, allowing the water to more easily traverse the gutter during the second and third trials.

Table 5. Test 3. Water Captured by Section

Trial #	Water Poured fl. oz	Left PVC fl. oz	Middle hose fl. oz	Right PVC fl. oz
1	24	22	23	24
2	24	23	23	24
3	24	23	23	24

In this test, we analyzed the gutter's performance when water was poured into different parts of the gutter, those parts being the left-most PVC pipe, the flexible hose tube, and the right-most PVC pipe. We observed that water capture was consistent across each section of the gutter. Differences in the quantities captured could be attributed to water getting stuck as it traverses the flexible hose tube, which would be corroborated by the results gathered from the tests with the Right PVC pipe, which observed a 100% success at water capture, as water spilled directly into that portion of the gutter did not need to traverse the flexible hose tube.

Figure F.2. Bucket Catches All of the Water

A 24 fl. oz water bottle was used to conduct tests. Due to a lack of accurate volume measuring materials, measurements for volume collected are rounded.

Test 4: Adjustability measurements

- Length
    - Hose tube adjustability: 9 - 50 in
    - Total gutter adjustability: 26.5 - 67.5 in
- Distance from table
    - Bracket adjustability: 2.75 - 5.5 in

Adjustability measurements were taken on the final design with a measuring tape.

APPENDIX G: Bill of Materials

Table 6. Bill of Materials

Item	Description	Qty	Source	Part #	Unit Cost	Total Cost
C clamps	Stainless steel, 1500 pounds tensile strength	2	Amazon	JK00206 F-9	$16.99	$33.98
Flexible hose tube	3-inch cold air intake pipe	1	Amazon	TZ20238 2	$15.99	$15.99
PVC Pipe	VENTRAL PVC Pipe Sch40 2.5 Inch (2.5) White Custom Length 2FT Feet	1	Segal Shop	PI000-43 -07-2530 -001	$21.93	$21.93
Sheet Metal	Hillman 12-in x 24-in Steel Solid Sheet Metal	1	Segal Shop		$11.48	$11.48
Nuts	1/4 in.-20 Zinc Plated Hex Nut	8	Segal Shop	801736	9¢	72¢
Bolts	1/4 in.-20 x 1 in. Zinc Plated Hex Bolt	8	Segal Shop	800596	18¢	$1.44
					Total	$85.54

APPENDIX H: Instructions for Construction

Introduction

At the Rose Center, members and staff alike enjoy handmaking paper as a therapeutic activity. The challenge they are facing is an excess of water runoff from the table, causing the tiling to become damaged, due to the large volume of water required to make paper. This device addresses the Rose Center's problem through its gutter-like design, which catches water as it falls off the table and funnels it into a bucket at the end.

Features include:

- Adjustable length
- Adjustable distance from table
- Detachable from table

Materials

Table 7. Material List

Material	**Specifications**	**Quantity**
Stainless Steel Clamp	Length: 3.3" Upper Width: 2.2" Lower Width: 1.7" Maximum Clamping Length: 2.8"	2
PVC Pipe	Length: 20" Diameter: 2.5"	1
Flexible Hose Tube	Length Stretched: 36" Diameter: 2"	1
Sheet Metal	Length: 20.5" Width: 10"	1
Nut and Bolt	Diameter: .25"	6

*See Bill of Materials for more information

Tools

- Band Saw
- Mill - drill bit with .25” diameter
- Drill Press - drill bit with .25” diameter
- Filer
- Snips
- Metal Cutter
- Metal Press

Instructions

Making the Bracket (x2) - See Figure H.5 for a dimensioned sketch

1. Use the mill to drill a hole into the back of the clamp (Figure H.1)

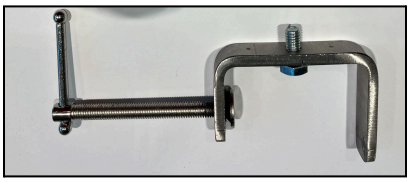

Figure H.1. Clamp

2. Cut the sheet metal into a rectangle of 7.5”x3.5”
3. Round the edges by using the metal press to fold over .25” one both of the shorter ends
4. Bend the middle of the sheet metal rectangle with a metal press to a 90° angle so that the longer side gets folded (Figure H.2)

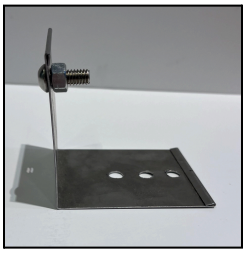

Figure H.2. Bracket 90° angle

5. Use a drill press to drill a hole with its center 1” down from the top and 1.5” in sideways on one folded edge of the bracket

6. Only in one of the brackets - use the drill press to drill a hole with its center .5” down from the top and .5” in from the left (this is the bracket pictured below)
    a. Screw a nut and bolt into this hole, with the nut on the inside of the bracket (Figure H.3)
7. In the other bracket - use the drill press to drill a hole with its center 1.5” down from the top and .5” in from the right
    a. Screw a nut and bolt into this hole, with the nut on the inside of the bracket
    b. Similar to Figure H.3, but with the top hole on the other side

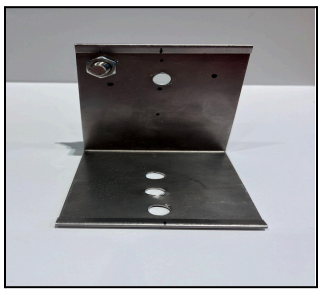

Figure H.3. Front View of Bracket

8. Use a drill press to drill a hole with its center .75” in and 1.75” in sideways on the other end of the bracket
9. Use a drill press to drill a hole with its center 1.5” in and 1.75” in sideways on the same end of the bracket as the previous hole
10. Use a drill press to drill a hole with its center 2.25” in and 1.75” in sideways on the same end of the bracket as the previous hole (Figure H.4)

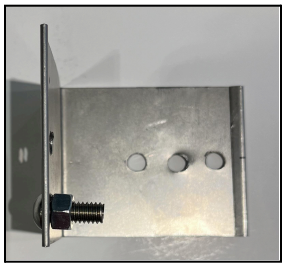

Figure H.4. Top View of Bracket

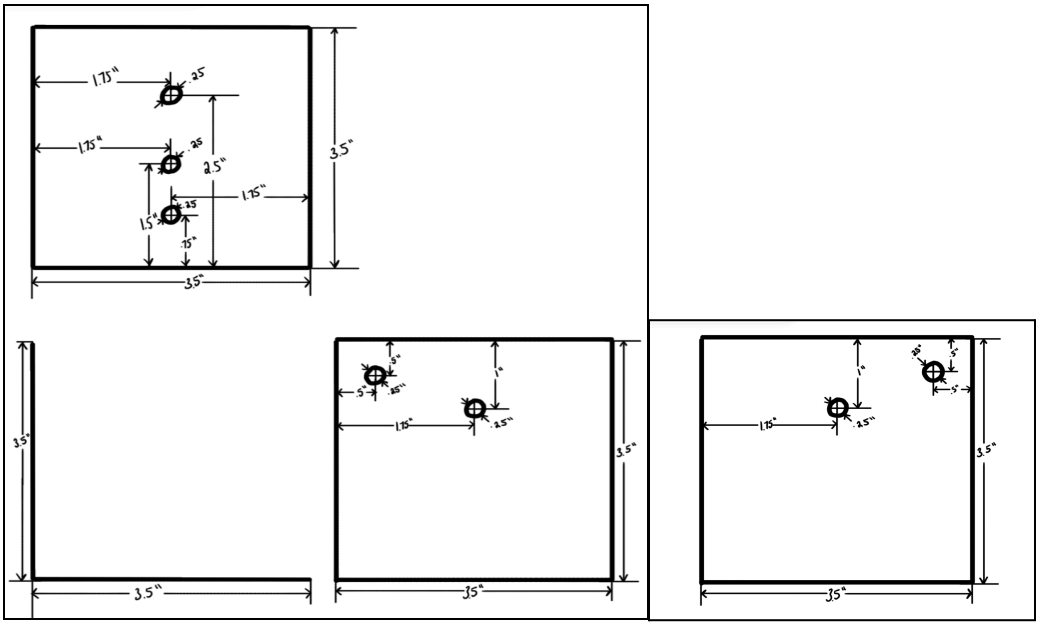

Figure H.5. Bracket Sketch

Bracket Mount (x2) - See Figure H.6 for a dimensioned sketch

1. Use a metal cutter to cut a piece of sheet metal into a 2.75”x1.5” rectangle
2. Use the drill press to drill a hole with the center of the hole being .25in down the longer side and .75” in from the side
3. Use the drill press to drill a .25” hole with the center of the hole being 1.5” down the longer side and .75” in from the side
4. Use the drill press to drill hole with the center of the hole being .25” from the other end of the longer side and .75” in from the side

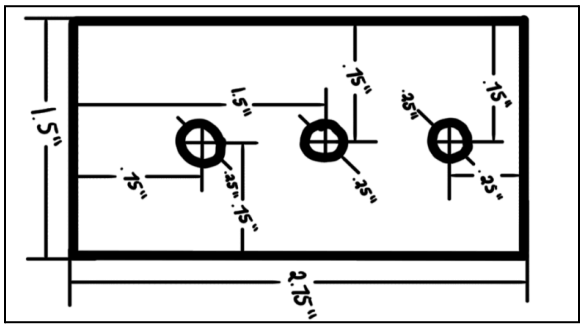

Figure H.6. Bracket Mount Sketch

Making the Gutter

1. Use a band saw to cut the PVC pipe down to 20” (Figure H.7)
2. Use a band saw to cut the PVC pipe in half along the long end in order to create the two gutter sections - Look at Figure H.9 for a dimensioned sketch

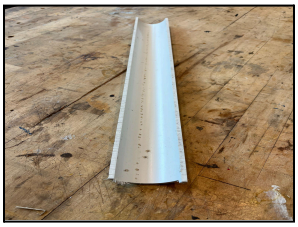

Figure H.7. PVC Pipe Gutter

3. Use a drill to drill a .25” hole into the bottom of the gutter on one side of each gutter piece. This hole should be an inch from the end and directly down the center of the gutter.
4. Use snips to cut the adjustable tubing in half, the same way as the PVC pipe
5. Use the snips to remove four wires inside the tubing on from end (Figure H.8)

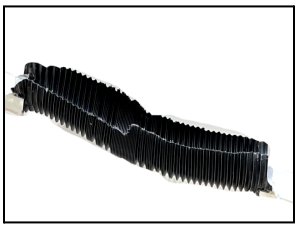

Figure H.8. Flexible Tubing Gutter

6. Use hot glue to connect the PVC gutters to either end of the tubing, with the sides without the screw holes attached to the tubing
7. Reinforce the connections with duct tape to ensure no water leakage

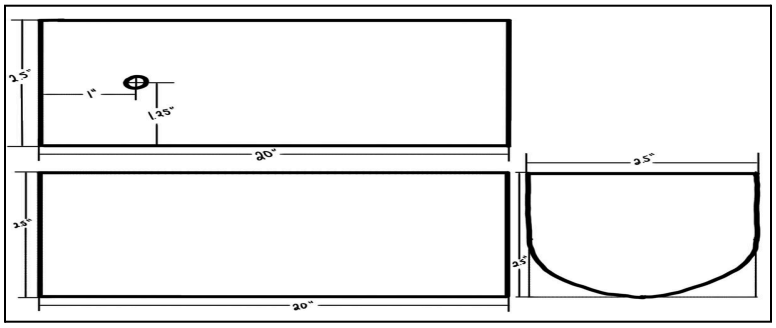

Figure H.9. Sketch of PVC Pipe

Putting It All Together

1. Use one of the nut and bolts to attach the clamp to the bracket mount, using hole from step 5 of the bracket instructions
2. Do the previous step to the other clamp and bracket mount (Figure H.10)

Figure H.10. Clamp and Bracket Mount

Safety Concerns and Potential for Error - Make mention of safety concerns or potential for error.

- If table clamp is made of stainless steel, using the drill press to create a hole will work harden the material causing smoke and sparks; to avoid this, pour oil over the clamp and use a mill to drill if available.
- The flexible hose tube was unwieldy and difficult to cut with the snips, requiring two people to do it safely.
- If someone is not careful while using the band saw to cut the PVC pipe, they could injure their hands.
- One could burn themself using the hot glue on the PVC pipe and flexible hose tube

APPENDIX I: Instructions for Use

1. Secure gutter to bracket mount using .25in diameter nut and bolt in the hole the closest to the end of the bracket (see Figure I.1)

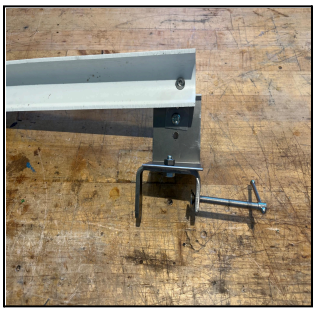

Figure I.1. Gutter and Bracket Mount

2. Repeat Step 1 on the other side of the gutter
3. Clamp to the table legs of the long side with the right side of the gutter sitting lower than the left side
    a. The nut and bolts that are screwed into just the bracket will allow for a specified incline in the gutter - may need to adjust accordingly how far down the left side sits
    b. Space between the table leg and clamp when clamping is a potential pinch point for fingers
4. Try spilling a bit of water off of the table and see if it lands in the gutter
    a. If so - all set!
    b. If not -
        i. Unscrew the gutter from the bracket on each end, move it one hole inwards, and re-screw the gutter into the bracket
        ii. Repeat Step 4