

## DEVELOPMENT OF DRAIN CLEANING DEVICE

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### ABSTRACT

Mechanical drain cleaner is offered as a replacement for human drainage cleaning. Cleaning the drain using the usual tool like drain hoes and rubbish pickers was ineffective and can be picked rubbish in small amounts. Furthermore, people or laborers also easily catch infections due to a large amount of waste in the drain. Therefore, this study aims to design a product that can be picked up rubbish from the drain using SolidWorks software and fabricate a drain-cleaning device. In this product, the system consists of metal teeth jaws that wait at the bottom of the mechanism. A motorized shaft connected by a chain to the jaws elevated the jaw at predetermined intervals. The jaws then reached the top and the waste dump into the basket. In conclusion, this drain cleaner device wayed more effective than the usual one and can prevent the high risk of infections.

**Keywords:** Drain Cleaning Device, Mechanical Engineering Design, House of Quality, Morphological Method, Pugh Method

### 1. INTRODUCTION

Cleaning the drain has always been challenging. People or laborers cleaning the drain without tools seems unethical and leads to a high risk of catching infections. Also, many of rubbish like bottles and plastics can lead to the narrowing of the drain and eventually blockage the gutter flow. Many revolutions of the tools were created yearly to ease ways to clean the drain. It was necessary to clean the drain before it became clogged. However, before there had some tools, there was just collected rubbish manually. It was dangerous because many kinds of bacteria flowed in that water. Therefore, many creators created machines that could clean the drain automatically to prevent this disease from attacking many people.

Sharma [1] has reviewed for few researchers and they agreed that the drainage pipe systems were filthy as it contains many organisms that can cause harmful diseases. When it times to the cleaning process, it may endanger human life. As a result, they developed the mechanical semi-automated drainage cleaner, ensuring the water flow was efficient due to the project's frequent waste filtration. With the help of a drainage system machine, various environmental hazards could be reduced.

Khin et.al [2] proposed an auto-mechanism system used to clean and control the drainage level consisting of a hand wheel, chain, driver, bucket, and frame. This automatic drain cleaner is widely used in domestic and industry due to its simplicity and ease of construction. As for Anbazhagan et al.[3], he produced an automatic drain cleaner to keep the water clean for daily needs. In order to maintain to have

clear water, the draining system needs to be in good condition to prevent impurities in the water system. This automatic drain cleaner may reduce human effort, especially for sewage cleaners.

Manual drain cleaners were a standard cleaning tool used to clean a drain at many places such as schools, houses and universities. It is widely used as it is cheap and affordable for ordinary people. One of the advantages of drain cleaner is that it is easy to store as it is small and does not have many parts to assemble. Meanwhile, the disadvantage of this drain cleaner is it is hard to handle due to its heavy weight. Other disadvantages of the automatic drain cleaner have been discussed by Sharma et al.[4] such as it required continuous power to run, the containers needed to be cleaned periodically, incorrect material and design selection and the main concern is the rusting system.

Bharathi et al. [5] have suggested factors for determining the materials choices in fabricating their drainage cleaning machine, such as the material properties and quality, manufacturing case, material availability, space consideration and the total cost for the machine construction.

The material used in this product was steel. Steel was the only material used to make this product. Steel was an alloy made up of iron with typically a few 10% carbon to improve its strength and fracture resistance compared to others of iron. It was widely used in this industry because steel was high in strength and low in cost. But most steels were susceptible to corrosion when exposed to air and watered. Hence to overcome it, therefore steel must be periodically painted. The other material used in making this product was rubber. The rubber is used at the claw because the material of rubber prevents it from slipping. Rubber was good tensile strength and tear resistance. However, to excellent wore resistance, rubber also offers low permanent set characteristics and is good at flexing qualities at low temperatures.

Blocked drain has been a problem for several people that left the waste out of ignorance. It becomes better if the drain is cleaned regularly. People also seem to be scared of catching infections or being poisoned due to the abundance of chemicals in the drain. A lot of other tools could have been more efficient to use. Throwing a plastic bottle or other objects leads to the drain narrowing and eventually blockage the drain flow. Chaudhari and Gajare [6], have designed and fabricated a semi-automated drainage cleaning machine to replace the manual cleaning method. It is approved that the machine separates the solid waste from the drainage water as it avoids the blockage of drainage lines and flooding.

The blocked drain was a common thing that happened in our society. It took a lot of work for people to take responsibility for our environment. Hence, this study aims to design a product that can pick up rubbish from the drain using SolidWorks software and fabricate a drain cleaner in order to reduce the possibility of a clogged drain.

## 2. METHODOLOGY

Figure 1 shows the flow of making this product from the start until fabricating and testing the product. This design project begins with the problem definition and needs identification. These activities aim to understand the design problem clearly and as a result, the Product Design Specification (PDS) table is produced. The PDS table serves as a guideline throughout the engineering design process. Once the PDS table is created, several concepts are generated using the Morphological Method. Subsequently, the Pugh Method selects the most suitable concept as the final design solution. These activities collectively form the conceptual design stage, where different ideas are explored and evaluated. After selecting the concept, the project progresses into the embodiment design phase. In this stage, the specific locations of each part within the product architecture are determined. Subsequently, for the in-house designed parts, the configuration design activities are carried out to identify suitable materials and manufacturing processes and finalize the part's shape. Parametric design techniques are then applied to determine part dimensions and specifications. Based on the design

specifications, a three-dimensional (3D) model is created using Solidworks software. Finally, in-house fabrication is done to create the prototype of the drain cleaning device.

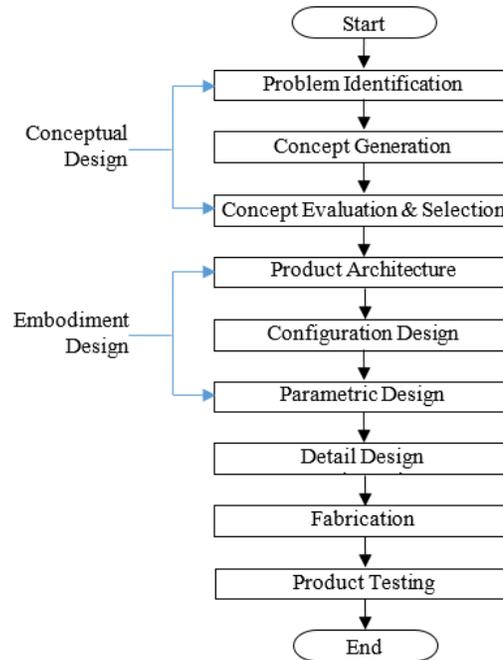


Figure 1: Flowchart of the design process

## 2.1 Problem Identification

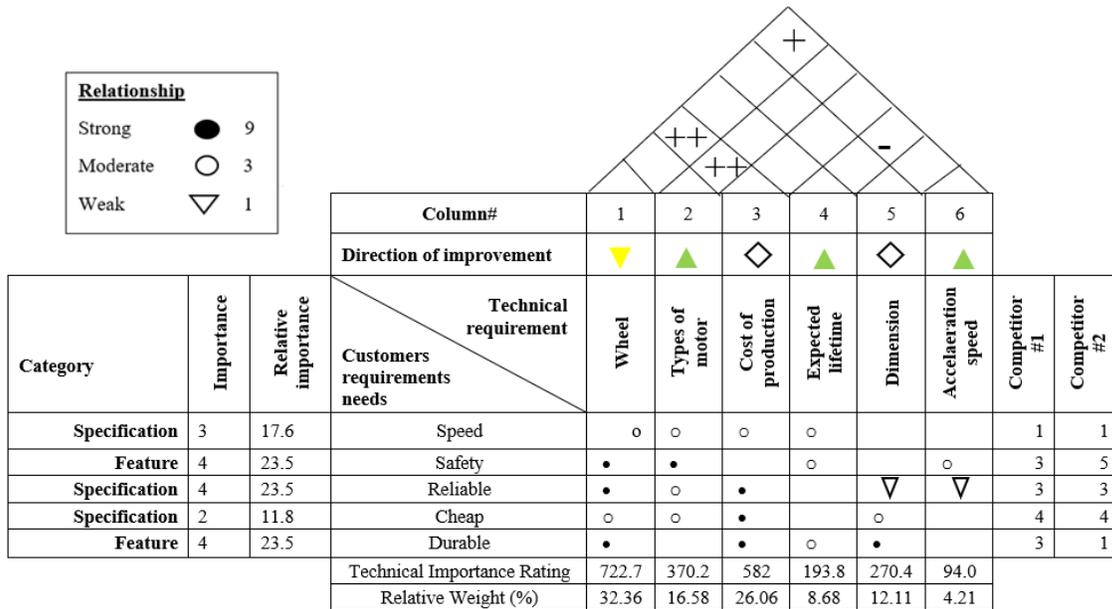
The design activities started with observation and interview of the cleaners workers in UiTM Cawangan Terengganu Kampus Bukit Besi. As a result, the identified problem related to drain cleaning activities is shown in Table 1 below.

Table 1: Problem-related to Drain Cleaning by Cleaners Workers in UiTM Cawangan Terengganu Kampus Bukit Besi

No	Problem
1	The current drain cleaning method is to take the rubbish manually and scoop it. This lead to back pain for the workers.
2	It takes more energy and time to clean the drain manually.

House of Quality (HOQ) is one of the four steps available in the Quality Function Deployment (QFD). The HOQ phase feeds the results into the design of individual parts, giving inputs into the design stage process, which later becomes an input into the production phase of QFD [7]. Table 2 below shows the HOQ related to customer requirements with the technical requirements for the drain cleaner device.

Table 2: House of Quality for Drain Cleaner Device



Based on Table 2, the primary concerns for customers regarding drain cleaner devices are safety, reliability, and durability, each with an equal relative importance of 23.5%. Regarding technical requirements, the most significant concern is selecting the appropriate wheel type compatible with various drain surface types, which holds a high technical importance rating of 32.36%. This ensures the device's effective operation on any surface. Another important consideration is the cost of production, which holds a substantial technical importance rating of 26.06%.

## 2.2 Product Design Specification

The Product Design Specification (PDS) for the drain cleaning device is provided in Table 3 below. The PDS outlines the key parameters that have been considered during the development of the device. Table 3 presents a comprehensive list of eight (8) factors that must be considered when designing the drain cleaner device. Each factor and its corresponding explanation are displayed in the table for easy reference and understanding.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Concept Generation

The Morphological Method is used for the concept generation activities for the drain cleaning device. This method can represent and identify the relationships in multidimensional problems. Table 4 shows the Morphological Table of the drain cleaning device. A total of four concepts are produced from the Morphological Table. The details of the combination of option-solution for each sub-functions are shown in Table 5 below.

Table 3: Product Design Specification for Drain Cleaners Device

No	Factor	Explanation
1	Performance	This product can collect rubbish like bottles and plastics using the jaws. It also can store more rubbish than usual products. This product just used very low power since it will only rotate once or twice a day to dump solid waste.
2	Environment	This product is subjected to a standard outside environment. (T= 24°C – 31°C , 85% - 93% relative humidity) Very minor dust condition. Have dirt and insects Have corrosive fluids & chemicals Have vibration and noise due to the movement of the chain Bearing-in tyres are expected to wear out over a long period of time. Have to regularly check the product because the main material is steel.
3	Maintenance	This product needs maintenance to ensure this product always operates without any problems. The part that needs maintenance is the chain, jaws, and dc motor.
4	Size	50 x 60 x 45 Centimeters
5	Aesthetics and finish	For this product, the appearance does not that matter because the customer's purpose is to find products that have great function for them.
6	Material	The special material used is stainless steel. Stainless steel is used because it can stand corrosion better than steel. So, it makes this product a long lifespan. Tires are to move this product.
7	Ergonomics	The product is easy to operate and handle and adjusted caused it just needs to be moved using tires The product needs to inspect every month and it's just can be handled by adults.
8	Reliability	The product executes its intended purpose for the consumer, while reliability refers to how well the product keeps its original quality over time and under diverse conditions. The product has a long lifespan if regularly inspect for all the components.

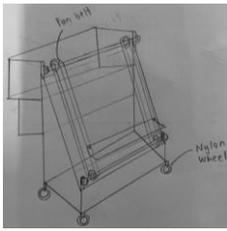
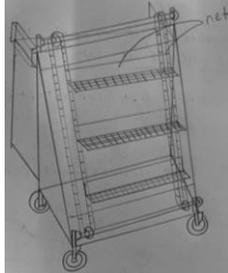
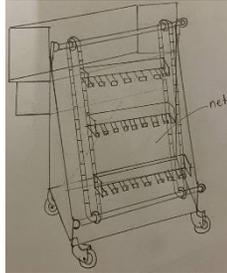
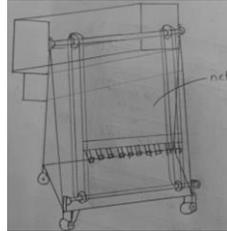
Table 4: Morphological Table

Sub-function	Option Solution 1	Option Solution 2	Option Solution 3	Option Solution 4
<b>Body</b>				
<b>Chain</b>	Belt	Chain		
<b>Jaws</b>	One Jaw	Multi Jaws		
<b>Jaws Design</b>				
	Jaw Design 1	Jaw Design 2	Jaw Design 3	Jaw Design 4
<b>Basket</b>				
	Basket 1	Basket 2	Basket 3	Basket 4
<b>Wheel Material</b>	Nylon	Rubber	Steel	Stainless Steel

Table 4 identifies five sub-functions for the Drain Cleaners Device: body, chain jaws, jaws design, basket, and wheel material. Each sub-function is accompanied by a minimum of two option solutions, offering a range of choices for consideration.

Table 5 shows four concepts generated using the Morphological Method. The table also provides a comprehensive overview of the combination of option-solution for each sub-function. This results in the creation of distinct and unique shapes representing each concept.

Table 5: Details of the combination of Option-Solution for each Sub-functions of Drain Cleaning Device

		Concept 1	Concept 2	Concept 3	Concept 4
<b>Sketches</b>					
<b>Sub-Function</b>	<b>Body design</b>	Body Design 1	Body Design 2	Body Design 1	Body Design 2
	<b>Chain</b>	Fan belt	Chain	Chain	Fan belt
	<b>Jaw</b>	One jaw	Many jaws	Jaws 2	Jaw 1
	<b>Jaw design</b>	Design jaw 1	Design jaw 2	Design Jaw 3	Design jaw 4
	<b>Basket</b>	Basket 1	Basket 2	Basket 4	Basket 3
	<b>Wheel material</b>	Nylon wheel	Rubber	Stainless steel	Steel

### 3.2 Concept Selection

The Pugh Method, also known as the decision matrix method, is used to evaluate and select the most suitable concept for the prototype of drain cleaning devices. This method effectively assesses the extensiveness and understanding of criteria, facilitates the rapid identification of the strongest alternatives, and encourages the exploration of new alternatives [8]. Table 6 presents the Pugh Charts for the concept selection of the drain cleaning device. Each criterion is assigned a weightage from 1 to 3 based on the prioritization of specifications required for the automated drain cleaner. Fifteen (15) criteria were utilized for the evaluation process.

Based on Table 6, the net scores for Concepts 1, 2, 3, and 4 are 4, 1, 7, and 6, respectively. As a result, Concept 3 emerges as the highest-scoring option. Concept 3 incorporates Body Design 1, allowing unobstructed water flow to prevent debris from getting stuck underneath. Additionally, it utilizes a chain capable of functioning effectively in wet conditions. Concept 3 also employs Jaw Design 3, ensuring collected debris remains in place while allowing excess water to pass through the holes. Basket 4 enables a larger capacity for collecting rubbish, and once the basket is complete, the compressed rubbish allows for further accumulation.

Table 6: Pugh Chart of Drain Cleaning Device

Description		Concept 1	Concept 2	Concept 3	Concept 4
Criteria	Weightage				
Durability	3	+	+	+	+
Safety	2	+	+	+	+
Simplicity	2	-	-	-	+
Affordability	1	+	-	+	0
Reliability	1	-	-	+	0
Ergonomic	2	-	0	0	-
Strength	2	-	+	+	-
Weight	2	+	+	+	+
Mobility	2	+	-	+	+
Ease of assembly	2	+	-	+	+
Reparability	2	+	-	-	+
Excitement	1	-	0	+	0
Aesthetic	1	-	+	0	0
Environment	2	+	+	+	+
Mechanical parts	1	+	+	-	0
	+	9	7	10	8
	0	0	2	2	5
	-	6	6	3	2
<b>Net Score</b>		<b>4</b>	<b>1</b>	<b>7</b>	<b>6</b>

### 3.3 Embodiment Design

In the Embodiment Design stage, significant attention is concentrated on defining the product's shape, dimensions, and tolerances. This stage involves three key phases: product architecture, configuration, and parametric design. In the product architecture phase, schematic diagrams and rough geometry layouts are developed to determine the optimal placement of each component within the product. Figures 2 and 3 show the collection of schematic diagrams and the rough geometry layout of the drain cleaning devices. As a result, the drain cleaning device is divided into four main modules: the wheel moves module, the shaft moves module, the movement module, and the frame module.

The positioning of the modules is determined by specific reasoning as follows:

- i. The collector bin is strategically placed at the top of the frame to allow the jaws to bring the rubbish upward and deposit it into the bin. This location ensures efficient collection and containment of the debris.
- ii. The jaws are located along the chain, enabling them to move and collect rubbish from the bottom of the frame. This arrangement ensures the jaws can effectively grasp and remove debris during cleaning.
- iii. The proximity of the shaft and motor is considered, aiming to facilitate smooth movement of the chain and the attached jaws. Placing them near each other makes the operational mechanism more efficient and ensures the device's optimal functioning.

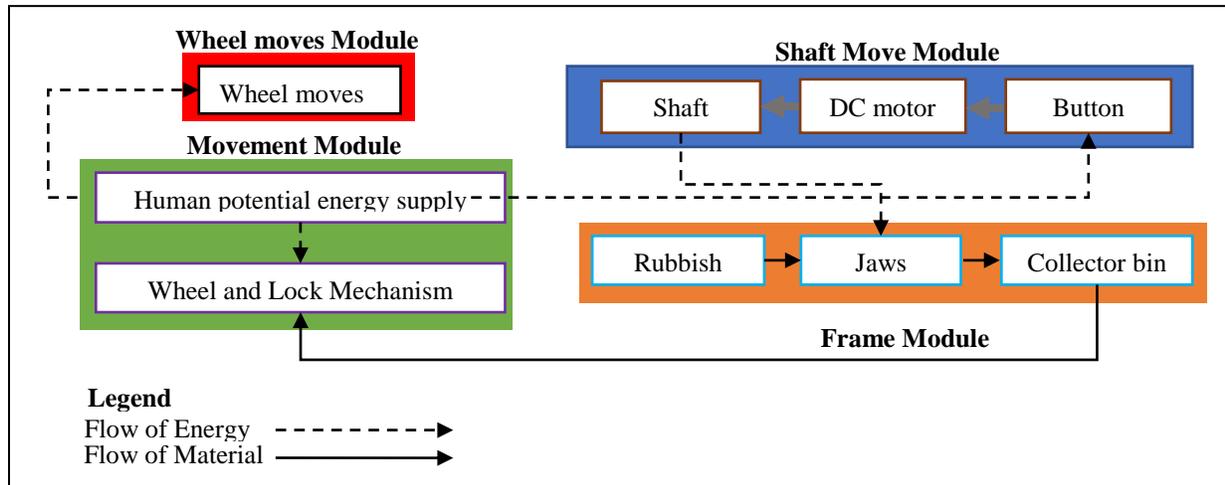


Figure 2: Clusterd Schematic Diagram of Drain Cleaning Device

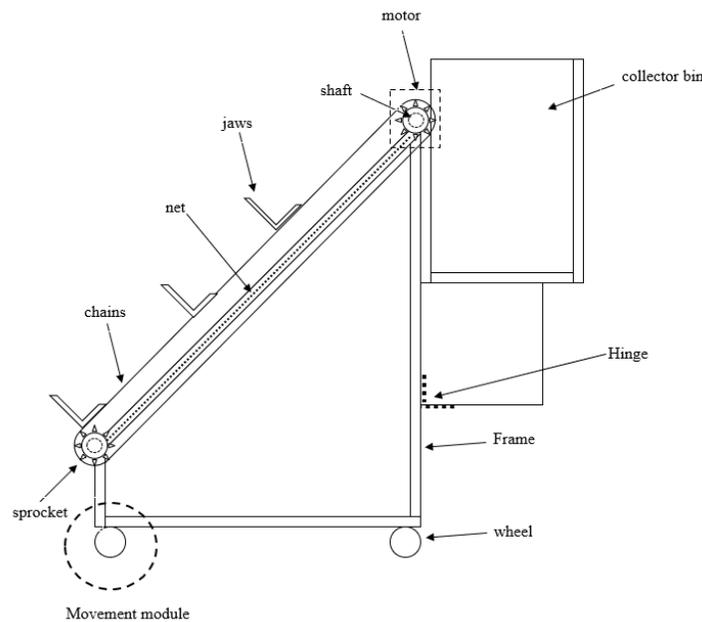


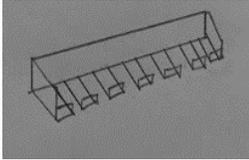
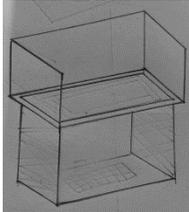
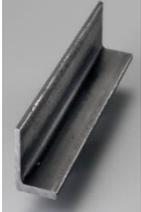
Figure 3: Rough Geometry Layout of Drain Cleaning Device

Configuration design covers several aspects of designing components, such as material selection, functional requirements, and manufacturing processes. In the case of this drain cleaning device, three specific parts require custom design and in-house fabrication due to their unavailability in the market. These parts have been identified as crucial for the device's operation. Table 7 shows a comprehensive overview of the configuration design details for the drain cleaning devices.

### 3.4 Detail Design

Figure 4 shows the Drain Cleaning Device's three-dimensional (3-D) modeling. The design was created using Solidworks software, which has 50 x 60 x 45 cm dimensions. This model represents the device's physical structure and helps understand its form and dimensions.

Table 7: Configuration Design for the Three Special Parts of Drain Cleaner Device

Name of Special Parts	Special Part 1 Design Jaw	Special Part 2 Collector Bin	Special Part 3 Leg at Frame bed
<b>Function</b>	To collect rubbish.	To place the rubbish.	Support the body of the product
<b>Material</b>	Steel	Steel	Steel
<b>Manufacture process</b>	Drilling process Bending process	Drilling process, Bending process, Welding process	Cutting process
<b>Suggestion Shape of Special Parts</b>			

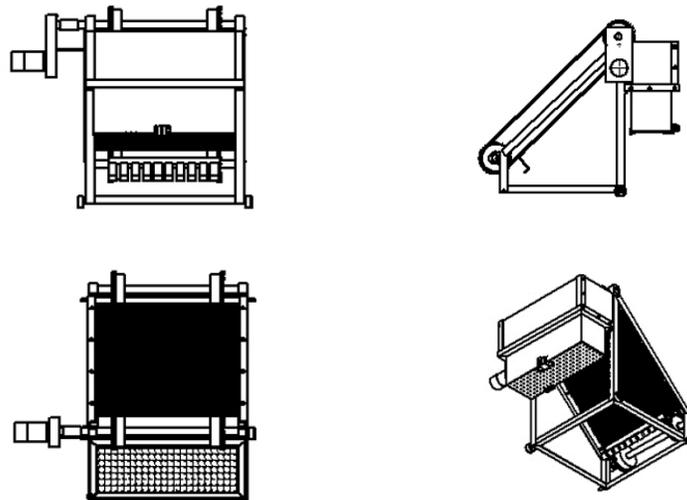


Figure 4: Three-Dimensional (3-D) Modelling of the Drain Cleaning Device

### 3.5 Prototyping

Figure 5 shows the fabrication model of the Drain Cleaning Device. This drain cleaner connects a direct current (DC) motor to a battery. When the shaft rotation is started, it subsequently drives the sprocket. The rotation then transfers to the chain, resulting in its movement. The collector jaws efficiently gather the rubbish at the bottom of the drain and bring the collector jaws to the top with the chain's assistance. At the top, the collector's jaws release the accumulated rubbish into the collector bin. These processes are repeated until the DC motor is disconnected from the battery, ensuring efficient cleaning operations.



Figure 5: The prototype of the Drain Cleaning Device

#### 4. CONCLUSION

In conclusion, the drain cleaning device is successfully designed and fabricated in UiTM Cawangan Terengganu Kampus Bukit Besi. Amongst the advantages of this cleaning device is, it uses the motor to move the rubbish to the collector bin. The device is also easy to move due to its moveable capability. This benefits the cleaning workers in terms of ease of back pain and avoids from catching infections from the drain. For further research, it is recommended to improve the collector bin to be wider so that can collect more rubbish. This improvement makes the drain cleaning device more effective because it does not require throwing the rubbish many times per use.

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