MDB 3063 ENGINEERING TEAM PROJECT

EXTENDED PROPOSAL

" TRIPLETAP "

BY

GROUP 84

NAME	PROGRAMME	ID
CHAN TIAN WEN	EE	25298
EZZAT BIN AZMAN	CV	24915
IMAD FITRI BIN FAZIL	CE	25326
MUHAMMAD ADIB BIN ADZAMAN	ME	25347
NURUL SHUHADA BINTI ABDUL RAHMAN	CE	25183

SUPERVISOR : DR HAYLAY TSEGAB GEBRETSADIK

SEPTEMBER 2019

UNIVERSITI TEKNOLOGI PETRONAS

32610 SERI ISKANDAR

PERAK DARUL RIDZUAN

TABLE OF CONTENTS

1.0. INTRODUCTION

1.1 Background

Industrialisation, rapid population growth, urbanisation and agricultural modernisation (among other factors) have caused the global rise of critical concern regarding the supply of water. Advocation for clean water and sanitation in the community has become so crucial that it was declared as one of the key areas of the United Nations Sustainable Development Goals (Nations, n.d.) Therefore, the term *water security*, defined as the availability of an acceptable quality and quantity of water for health, livelihoods, ecosystems and production, has been deemed the solution to sustain the supply of clean water and sanitation.

The world is now urging for an increased investment in management of freshwater ecosystems and sanitation facilities on a local community level, especially in developing countries such as those found in Sub-Saharan Africa, Central Asia, Southern Asia and Malaysia's very own region, Southeast Asia. Malaysia is currently blessed with continuous water supply due to the abundant rainfall that averages 3,000mm annually, which contributes to an estimated annual water resource of some 900 billion cubic metres. Our neighbour Singapore, however, has a high water-stress ranking due to its dense population and lack of freshwater lakes and aquifers (Reig, Maddocks, & Gassert, 2013). Singaporeans worry about water management every day, while Malaysians tend to take water for granted. Such a juxtaposition highlights the importance of water conservation.

Realizing the gravity of the situation and our position to do something about it, our Engineering Team Project GROUP 84 came together to conceive an idea that targets the two sub-goals of UN Goal 6 : Clean Water and Sanitation,

- Target 6.5: Implement integrated water resources management
- Target 6.B: Support local engagement in water and sanitation management

Our prototype – *TripleTap*, revolutionizes the humble tap by providing water-saving and sanitation features. The name of our product is derived from two things,

1. its mechanism, which has three flexible spray settings for three different flow rates – hand washing, kitchen washing, and standard washing
2. the term *triple threat*, a performer who excels in singing, dancing and acting

1.2 Problem Statement

These are some of the problems identified with the current conventional water tap:

- Traditional taps are hand-turned, which poses a hygiene risk.
- Manual taps are more likely to drip than sensor taps.
- Manual taps are less water-saving than sensor taps.
- Both sensor and manual taps have only one permanent flow rate for different activities, making them not flexible.

1.3 Objectives

TripleTap aims to achieve the following objectives:

- Ensure user sanitation in public and personal spaces
- Assist local community in overcoming excess water usage by providing target-specific water-saving features
- Providing a portable, user-friendly device for ease and convenience while saving the environment

2.0. DESIGN THINKING

2.1 Literature Review

According to Guppy and Anderson (2017), there will be a 40% gap between water demand and water availability by the year 2030. Although it is a well-known fact that water covers 70% of the planet's surface, it does not necessarily mean that water is *plentiful*, as only 2.5% of all water is freshwater. As our global population increases exponentially, there is an increasing urgency to solve the global water crisis, one that borders almost on desperation. To prevent water loss through leakage as well as promote water conservation in our daily lives, it is of vital importance that we begin by tackling the water supply system.

There are three main parts to a water supply system:

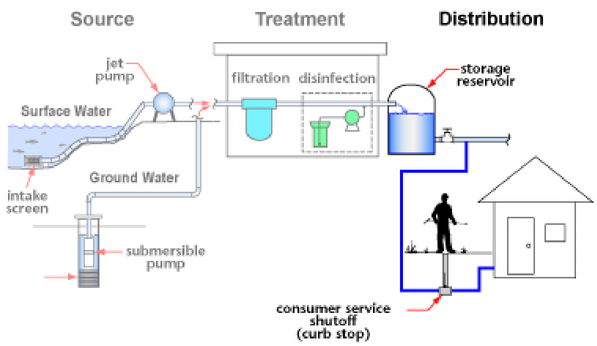


Figure 1

Naturally, the most visible part of this system is the final stage – distribution to end users. While there are many components in this stage, our team has elected to choose the most familiar of them all – the hand-turned tap.

Taps have long been one of the major sources of water loss, mainly due to the wide variety of activities that an individual may perform while using it – from handwashing and plate-washing to brushing your teeth. According to the United States Geological Survey, water from a faucet ranges from 1/5 to 1/3 of a millilitre (Brothers, 2019). Taking 1/4 millilitre as the average, and a leaking tap of one drip per second, it would take only four and a half hours to reach water loss of one gallon (3.78541 litres).

Rose (2017) discovered that when it comes to water usage, there is a huge disparity between traditional hand-operated taps and sensor taps. Traditional taps release up to 10-15 litres of water per minute, whereas sensor taps provide a lower flow rate that can dispense 70% less than traditional taps, or more. Sensor taps also provide a feature which traditional taps do not – they can prevent a mindless running tap. A YouGov survey by Middlesex University found that a third of the UK population have the tendency to leave their taps running while brushing their teeth. Meanwhile, waterwise.org estimates that a running tap can waste over 6 litres per minute. A quick calculation will no doubt conclude that just by brushing your teeth twice a day, for two minutes each, a third of the UK population would have let 24 litres of water go to waste. A sensor tap that triggers water flow only when an object is directly beneath it can prevent this sort of water wastage from happening.

Not only that, taps that have been outfitted with an aerator have been estimated to save up to 1274 litres per month. This number varies depending on the type of aerator and its mechanism – WaterSense labelled aerators can reduce water flow by 30%, whereas the Altered:Nozzle aerator boasts water savings of up to 98% without sacrificing performance. Thus, modern taps with appropriate accessories have proven to be much more environmentally friendly

Singapore's National Water Agency recently revealed their findings on household water consumption:

Figure 2

From this, we can clearly see that taps occupy roughly 40% of the chart – bathroom tap, kitchen, basin, others (tap leakage). By targeting 40% of this chart, we can ensure that a household conserves water and practise healthy water saving habits in at least 40% of their daily activities.

However, most of these modern faucets with water-saving features are disruptive to install when an existing tap is already in place. Although aerator nozzles can be easily screwed on, sensor taps do not offer the same convenience. A sensor tap requires the expertise of a plumber and, unless equipped with prior knowledge, is unable to be installed by a common layman.

Besides water-saving issues, traditional faucet handles also have questionable sanitation. By turning taps on and off, users run the risk of contaminating their already cleaned hands. Research has found that household faucet handles are a breeding ground for 56, 133 colony-forming-units (CFU) of bacteria, a number that reaches a staggering 3 million in public restrooms. This renders the hand-washing process redundant, as users who turn off the tap after contaminate their hands again. Sensor taps eliminate this risk.

TripleTap aims to resolve all issues mentioned above by providing a sensor tap integrated with an aerator mechanism. This tap can be easily installed on an existing tap without any need for heavy-duty procedures or external expertise. Not only that, it requires minimal maintenance and can provide information on how much water has been saved. With such a prototype, we hope that this encourages users to contribute toward saving the environment in a hassle-free manner.

2.2 Design Thinking Tools

a) *Analogous Inspiration*

Analogous inspiration is defined as "*a way to look for solutions in different contexts that may be applicable to your challenge or inspire an idea that is*." ("Analogous Research", 2018). Analogous inspiration can trigger ideas in sectors that might not be related to the original source of inspiration. For example, an algorithm initially created to match medical students to residencies became the basis for school assignment systems in major cities across the United States.

With analogous inspiration in my mind, our team sat down for a brainstorming session. We had already established earlier on that we would want to focus on saving water by making modifications to taps. To promote more original innovation, our team deliberately veered away from researching taps. Instead, we focused our energy on things that were distinctly *not* taps, but which may help in providing inspiration, such as water filters and automatic watering systems.

After about an hour, we were struck with analogous inspiration from the concept of the showerhead. Most modern showerheads have flexible spray settings that can be changed according to user preference eg power massage, mist and rain.

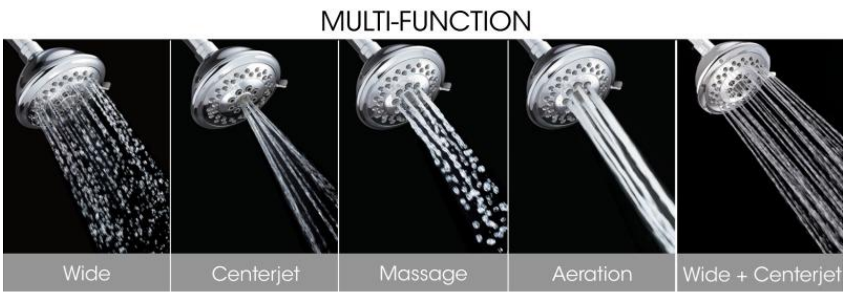


Figure 3

However, most users do not understand the significance of each setting and when to use them; thus, they rarely change the spray settings on their showerhead. Deriving inspiration from this, our team decided that if the user were to know the meaning of each mode or setting, he would be more encouraged to utilize it. That was when we came up with the idea of a three-mode tap – handwashing, kitchen usage and standard flow rate. Each setting dispenses the appropriate flow rate that is sufficient for the targeted activity, which saves water when compared to traditional taps. With this analogous inspiration, *TripleTap* was born.

b) ***Survey***

To gain more insight to our project idea, we decided to take a public survey. A total of 125 respondents from various ages (ranging from university students to parents) answered our questionnaire, and the results are as follows.

1) Do you think different sink activities require different volumes of water?

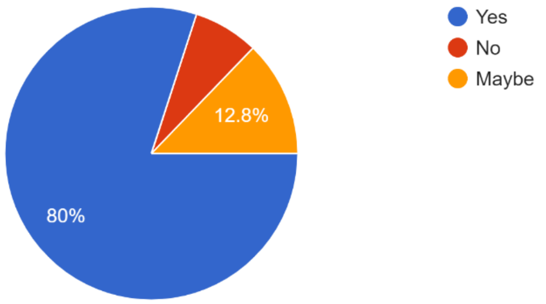


Figure 4

80% of respondents believe different sink activities require different volumes of water. If public opinion holds true, we can say that the traditional hand-turned taps that offer only one permanent flow rate causes wastage when used with activities that require lesser water flow.

2) How have you tried overcoming water wastage in your kitchen, bathrooms etc?

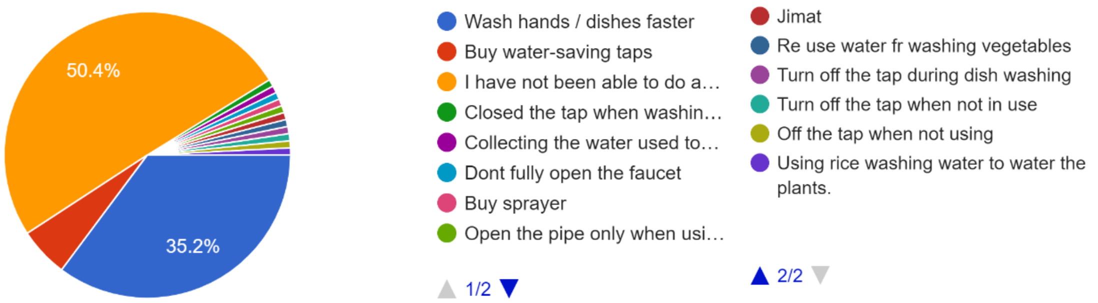


Figure 5

From this, we can see that more than half of the respondents have been unable to solve water usage. The most commonly applied action is washing hands and dishes faster, as done by 35.5% of respondents.

3) Have you had any experience with adjustable shower heads with different spray settings?

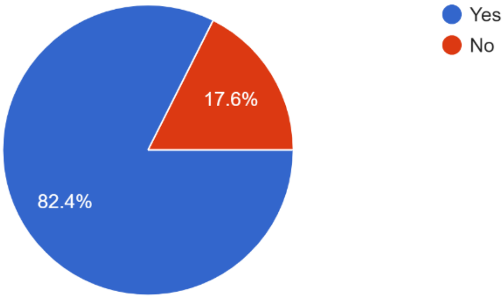


Figure 6

Showerhead with flexible settings are not unfamiliar to 82.4% of our respondents. This means that majority will be able to easily utilize our prototype without fear of confusion.

4) Do you know what is the use of each spray setting, their importance and how are they different from one another?

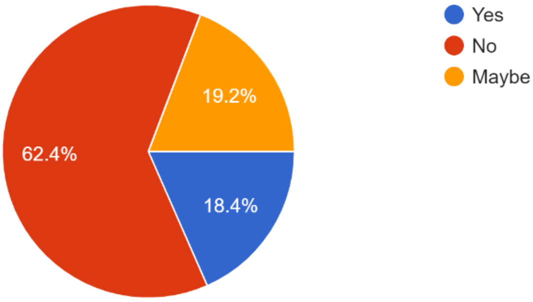


Figure 7

As we had suspected, majority of the public do not know or are unsure as to what each spray setting signifies, and what are they meant for.

5) Do you think knowing the usage of each mode will encourage you to select the correct mode for different activities?

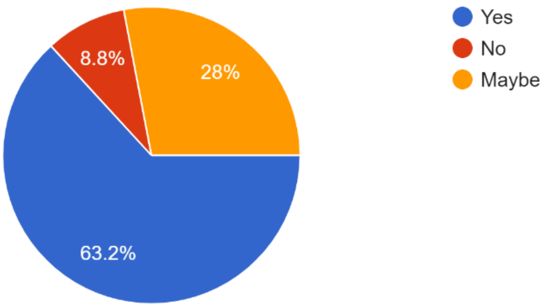


Figure 8

Majority of our respondents proclaim that knowledge of each mode and their differences will encourage them to use it more often.

6) When it comes to a water-saving tap feature, what do you look for?

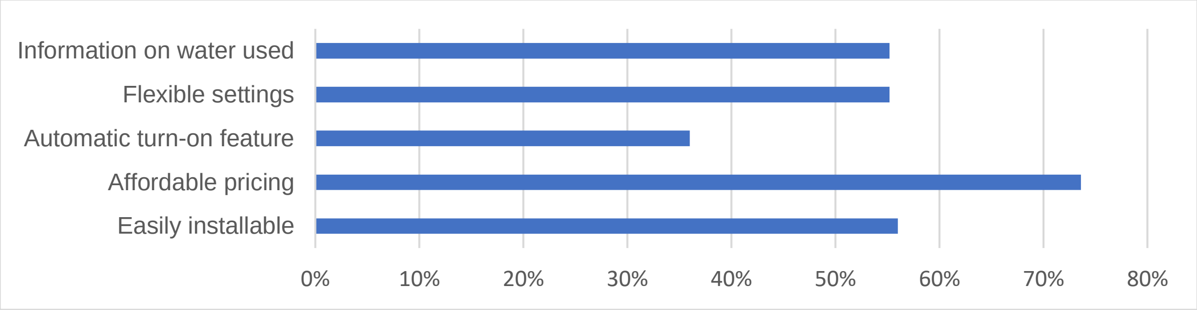


Figure 9

As expected, pricing remains the top concern among potential buyers. This is also why commercial sensor taps that are difficult to install do not attract much consumers as they must handle not just purchasing cost, but also the cost of hiring a plumber to do the installation. Easy installation and flexible settings are next in line in the public's priority, followed by information on water used and an automatic turn-on feature.

With this information, our team can build on the concept of a tap with flexible settings, by adding on features that the public has deemed most useful. In conclusion, we can gather that our product will have good market value as its applications are for a wide audience, contributes to the environment and satisfies the public's top-rated demands.

c) Experiments

To further determine the amount of water required for each type of sink activity, experiments were carried out as below.

Methodology of experiment :

1. Three random persons were selected to run this experiment. They were told to wash their hands per normal and the objective of the experiment was not explained to them to prevent unconscious bias.
2. A tank was placed in the sink to collect amount of water used.
3. The experiment was repeated with the following activities :
   a. washing hands with soap
   b. washing a plate with soap
4. The results for each person and experiment were tabulated and the average taken.

Individual	**Volume of water used (litre)**		
	Handwashing (no soap)	Handwashing (soap)	Plate-washing (soap)
A	0.80	1.00	2.20
B	0.60	1.20	2.50
C	0.70	1.50	2.30
Average	0.70	1.23	2.33

Table 1: The volume of water used for the activities based on individual

From the table, we can see that different individuals spend different amounts of time and water for the same activity. Handwashing without soap ranks lowest in water consumption, while plate washing ranked highest. Therefore, we can deduce that although water flow rate is identical, water usage per activity differs. This further strengthens our stand – which is that we do not find a single fixed water flow rate ideal in a multi-usage tap.

To conclude, our experiments have proved that different activities consume different volumes of water. The amount of water used per activity depends on individual preference; however, the results are comparable and do not possess a big difference between one another.

3.0. DESIGNING

To fulfil its purpose, *TripleTap* requires the following :

1. A mechanism to control and adjust the output water flow rate
2. Internal circuitry to sense presence of object and dispense water
3. Bluetooth connection to an external LCD screen display for water usage information

3.1 Alternative Design Concepts

DESIGN 1:

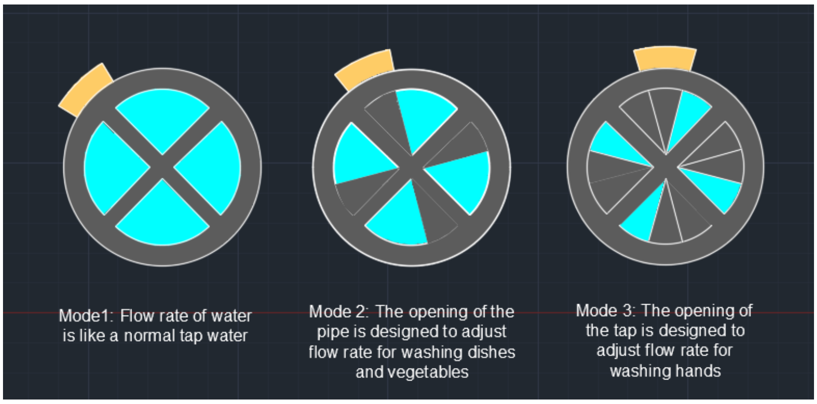


Figure 10

A four-part sector-shaped opening was designed, which can be connected directly to the mouth of the tap. The openings are controlled by three layers of metal pieces. A knob will be installed at the outer part of the tap, and a simple clockwise turn of the knob will trigger the next mode. Each turn of the knob results in 30° clockwise turns of specific metal pieces, which reduces the opening and the flow rate.

After deeper analysis however, we decide that this design would not be feasible as it would produce four separate streams of water, instead of one centred flow. Layering of three metal pieces also significantly increases the thickness of our inner mechanism. Finally, metal pieces of our desired size are difficult to manufacture and hard to shape as they are small in size. Thus, this design was scrapped and another made.

DESIGN 2:

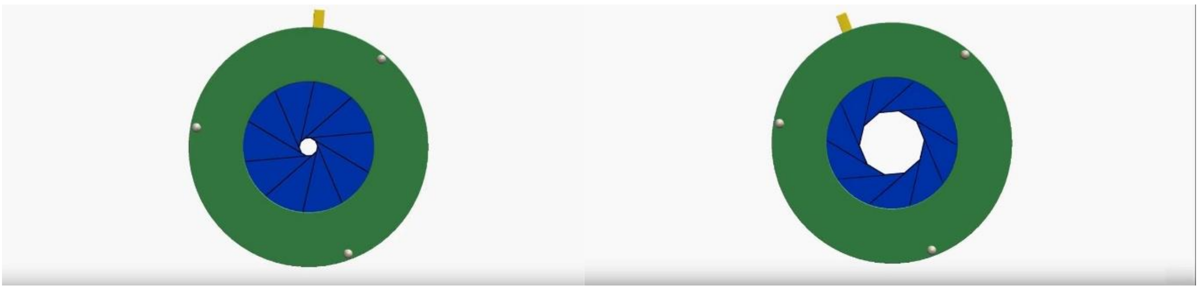


Figure 11

Unlike the previous design, this design utilizes the iris mechanism. Preliminary calculations put the inside diameter of the iris to range from 15 mm to 35 mm. Again, an external knob is used as means of adjustment. A clockwise turn decreases the opening and vice versa.

Although this does provide a centred flow, it also raises the issue of lack of surface area, especially when the flow rate is small – that is, the user will only be exposed to a small, center trickle while washing their hands. This is inconvenient. Hence, the next design was produced.

3.2 Finalized Design & Justification

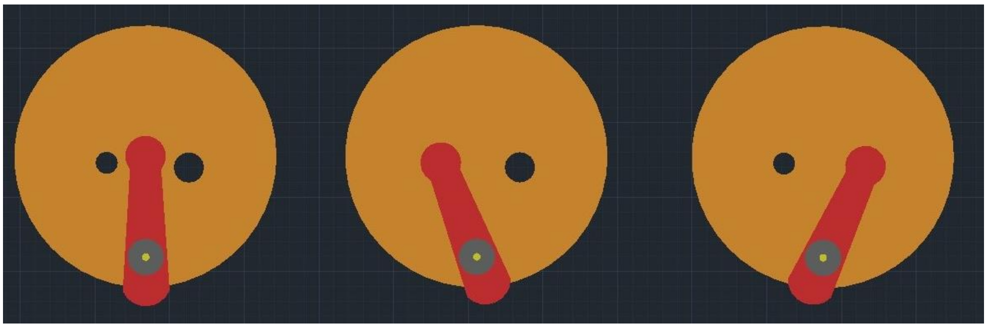


Figure 12

This design produces a jet mode, shower mode, and jet + shower mode, which solves the problem of surface area exposure. 2 holes are drilled, each with a different diameter – the smaller hole is 8 mm in diameter, whereas the larger hole on the right is 11 mm. Instead of a knob, we now have a lever that extends inward to the centre.

Centring the lever leaves both holes open, which produces jet + shower mode. This results in the largest flow rate of our tap, which although still lower than conventional taps, is sufficient for customer use. Turning the lever clockwise covers the bigger hole and leaves the smaller hole exposed, which triggers the smallest flow rate for handwashing. Turning the lever anti-clockwise does the opposite, producing the medium flow rate, for kitchen usage.

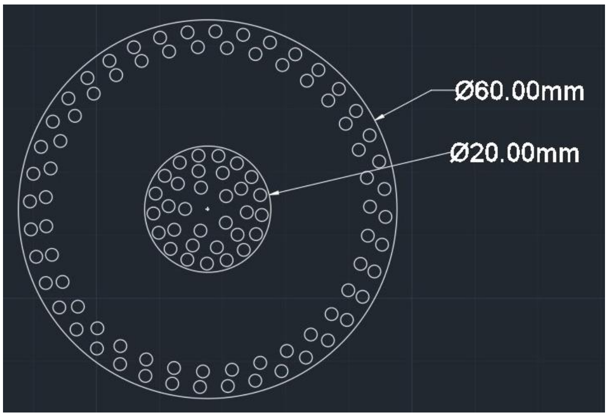


Figure 13

All streams of water flow through an aerator piece, which helps produce the jet and shower modes. As a conclusion, **DESIGN 3** overcomes the thickness problem of DESIGN 1 and lack of water surface area of DESIGN 2. It does all this while still fulfilling our objectives, and therefore, DESIGN 3 is our finalized mechanical design.

The schematic circuits involved in our prototype are as follows :

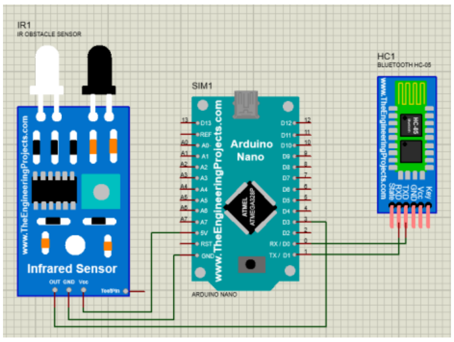
1. 

Figure 14

This schematic circuit provides the automatic turn-on feature. Arduino Nano is chosen for its compactibility and the Bluetooth Module communicates with an external LCD screen display.

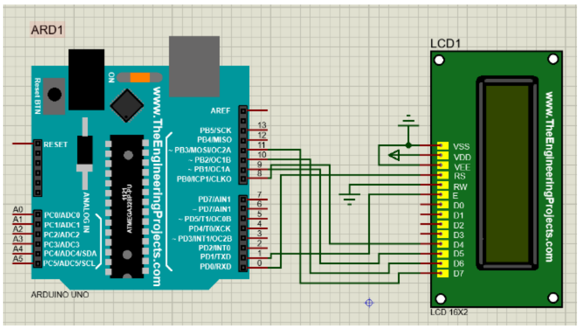
2. 

Figure 15

This schematic circuit refers to an external LCD screen that will display information on the user's water expenditure.

4.0. PROJECT MANAGEMENT PLANNING

4.1 Task Listing & Distribution

CHAN TIAN WEN (25298)

- **Project Director**
- Organize and coordinate team meetings
- Prepare Gantt chart and supervise project progress by forming weekly agenda
- Lead design of electrical circuits
- Identify items and prices of electrical components
- Conduct literature review
- Compile and proofread reports

IMAD FITRI BIN FAZIL (25326)

- **Secretary**
- Arrange weekly consultation sessions with supervisor
- Take attendance at each meeting and keep track of all deadlines
- Prepare relevant documentation eg minutes of meeting, lab bookings, ETP store
- Conduct background research on problem statement and objectives
- Conduct experiments to determine volume of water for each sink activity
- Conduct survey and questionnaire

NURUL SHUHADA BINTI ABDUL RAHMAN (25183)

- **Treasurer**
- Manage the account flow for this project and ensure all expenses are within budget
- Keep track of all expenses, invoice and bills
- Collect funds per member to contribute to project expenses
- Prepare forms necessary for claiming purposes
- Evaluate economical and business consideration of project
- Provide logistics assistance in purchasing components
- Conduct experiments to determine volume of water for each sink activity

MUHAMMAD ADIB BIN ADZAMAN (25347)

- **Technical work**
- Conduct research on similar products on market
- Design project interior
- 3D drawings with AUTOCAD
- Select and compare alternatives in materials
- Conduct research on related articles to support fabrication process
- Produced methodology / work flow

EZZAT BIN AZMAN (24915)

- **Technical work**
- Conduct research on analogous inspiration
- Design of project exterior
- Researching items and prices for construction of prototype
- Advise on choice of materials
- Identify tools and software used in fabrication and designing
- Testing and improvement of prototype

4.2 Gantt Chart (Activities & Milestones)

Task Details	1/9 7/9 W1	8/9 14/9 W2	15/9 21/9 W3	22/9 28/9 W4	29/9 5/10 W5	6/10 12/10 W6	13/10 19/10 W7	20/10 26/10 W8	27/10 2/11 W9	3/11 9/11 W10	10/11 16/11 W11	17/11 23/11 W12
ETP Briefing												
Design Thinking / Ice Breaking session												
First Supervisor Consultation												
Individual Reflection												
Brainstorming (SWOT analysis)												
Finalization of Project Idea												
In-depth Project Research												
Marketability Review & Research												
Experimental Data Collection												
Mechanism Phase I (Structural Design)												
Circuit Phase I (Schematic Design)												
Economic Analysis												
Extended Proposal First Draft												
Purchase of Materials & Equipment / Submission of ETP store form												
Proposal Draft Review												
Extended Proposal Final Submission												
Mechanism Phase II (Development of Prototype)												
Circuit Phase II (Development of Prototype)												
First Prototype Complete												
Mechanism Phase III (Refinement of Prototype)												

Circuit Phase III (Refinement of Prototype)												
Finalized Prototype												
Prototype Evaluation												
Form 03 Submission												
Presentation & Demo Rehearsal												
Poster & Product Demo & Presentation (Pre-SEDEX)												
Collection of endorsed Form 03 and complete full submission process to Finance												
Submission of Peer Evaluation Form												
Submission of Final Report												
Return of Prototype												

LEGEND

Completed	Due	Overdue

4.3 Feasibility Of Plan

The finalized design has been presented to the supervisor and given the green light to proceed. Sufficient research has also been conducted to ensure that cost-effective materials are used for building of our prototype, based on pricing and availability. Furthermore, there are many lab technicians at hand that can assist and guide us during the fabrication process.

Not only that, a week's time was allocated for refinement of prototype in the Gantt chart, to ensure that we are able to produce a fully-functioning prototype on time, while also having enough time to test it for flaws, make further amendments and resolve any technical or design issues. Labs with functional and sufficient equipment are available all throughout the process. Therefore, we believe the plan is feasible and will be able to proceed within the designated time frame.

5.0. METHODOLOGY

5.1 Project / Work Flow

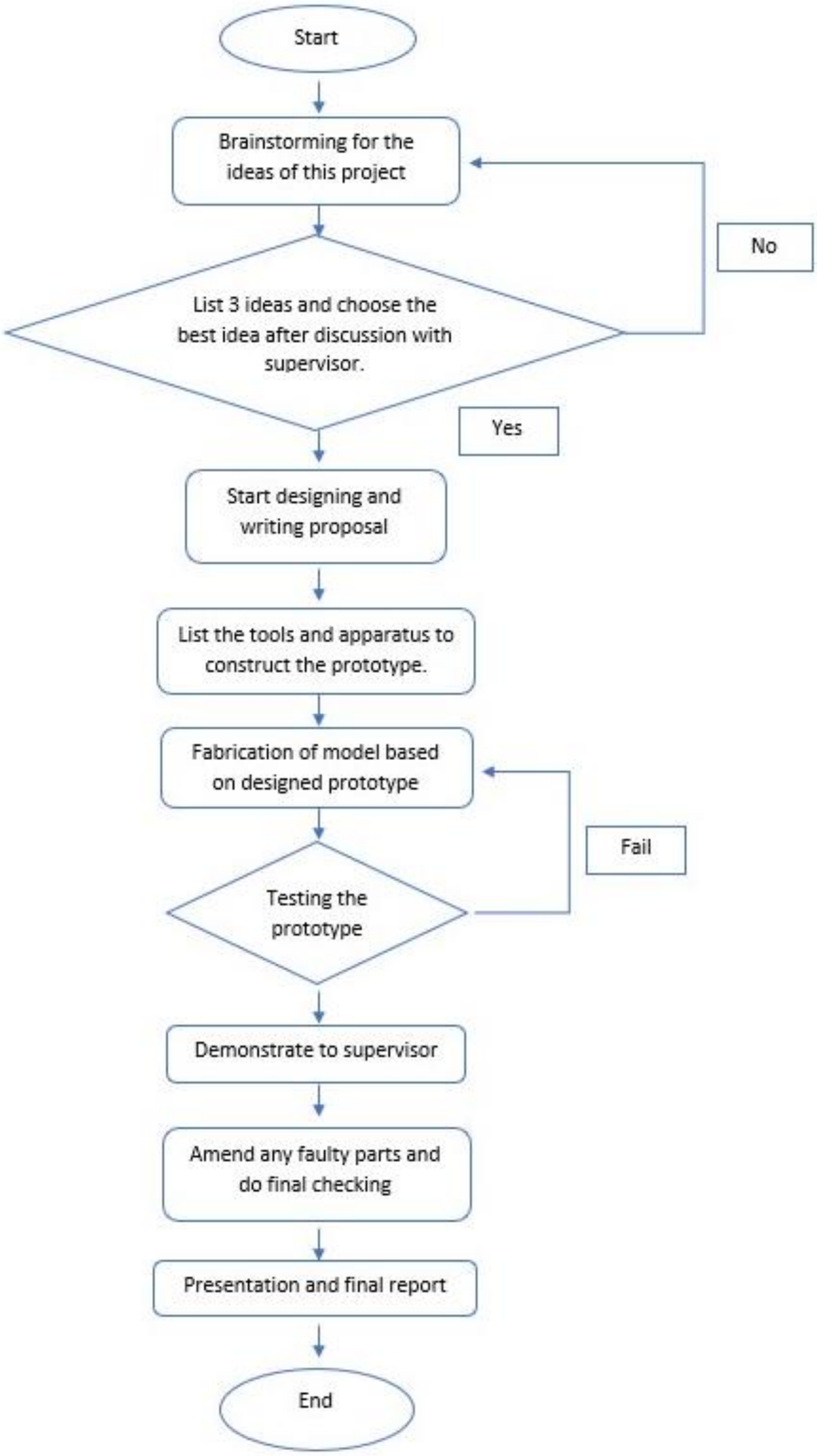
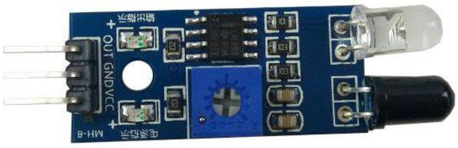


Figure 16

5.2 Identification Of Suitable Tools And Software

In this project, the suitable tools that we have chosen are listed below :

1. IR Sensor



For automatic turn-on feature of tap.

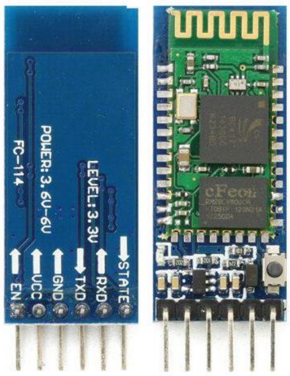
Figure 17

2. Arduino Nano

Compact microcontroller to be used within device.

Figure 18

3. Bluetooth HC05 Module



For communication between device and external LCD screen.

Figure 19

4. 3.7 rechargeable Li-On batteries

As power supply for our device.

Figure 20

5. ¼ inch solenoid valve

Figure 21

To restrict and open the water flow for our device

The software use for our project is as used below :

NO.	SOFTWARE	FUNCTION
1	AutoCAD	To draw 3D drawing of the prototype.
2	Proteus 8 Professional	Design and simulate schematic circuits.

Table 2

5.3. Justification Of Fabrication Choices

Plastic was chosen as the material of our prototype. Plastics are derived from natural, organic materials such as cellulose, coal, natural gas, salt and, of course, crude oil. The main reason why we choose this material is because it is a good electrical insulator. As our prototype is going to involve with electricity for the IR sensor and water which can conduct electricity, so choosing plastic as the material for the body is good for safety. Two main processes are used to produce plastics - polymerisation and polycondensation - and they both require specific catalysts. In a polymerisation reactor, monomers such as ethylene and propylene are linked together to form long polymer chains. Each polymer has its own properties, structure and size depending on the various types of basic monomers used.

Not only that, our prototype is also continuously exposed to water, and metals will rust. As our device is small and light, we decide that 3D printing will be cost-effective in producing the prototype in the amount of time we are assigned.

6.0. ECONOMICAL/BUSINESS CONSIDERATION

6.1 Capital Cost Consideration

UTP has allocated RM300 per team for this ETP project. This fund will be used to construct the prototype of our project. The following is the estimated budget for the fabrication of the prototype.

Estimated Cost for the Components of Triple-Tap

ITEM	PRICE PER ITEM	NO. OF ITEMS	TOTAL PRICE
3D printing filament	RM54.87	1	RM54.87
Arduino Nano	RM14.20	2	RM28.40
Battery holder	RM5.20	1	RM5.20
Solenoid valve	RM17.81	1	RM17.81
3.7V Li-On rechargeable battery	RM3.90	4	RM15.60
Multicore wires (1 metre)	RM1.80	1	RM1.80
IR sensor	RM4.00	1	RM4.00
HC05 Bluetooth module	RM13.80	2	RM27.60
LCD screen display with I2C	RM11.50	1	RM11.50
Stripboard	RM3.50	2	RM7.00
Total			RM173.78

Table 3

6.2 Operational Cost Consideration

The fabrication process does not require any operational cost as it is being incurred by UTP since it is conducted at Engineering, Prototyping and Innovation Centre in UTP itself. Once commercialized, the fabrication process will be run in a factory and it would not cost much as the production will be in bulk.

The daily usage of the device involves minimal mechanical movement and is constantly plugged into an AC power supply with a backup battery system that kicks in when there is a blackout. The battery system does not require user interference and charges by itself. Therefore, the daily operational cost is negligible.

6.3 Alternative Materials

Stainless steel can be used to replace plastic. Since the inner part will be continuously contact with water, this material can be chosen due to its excellent resistance to stain or rust due to its chromium content, usually from 12 to 20 percent of the alloy. In addition, stainless steel is widely used as the material for water supply piping. The manufacturing process involves melting and casting, forming, heat treatment, descaling, cutting, and finishing. Other than that, zinc alloy can also be used.

7.0. CONCLUSION

Excessive water wastage is threatening water security on a global level, especially in developing states. It is an issue that is of paramount importance and needs immediate attention. Therefore, smart innovations that are able to tackle and resolve this concern is greatly needed.

After thorough research and studies, our team has pinpointed a major contributor of water wastage – conventional water taps. This traditional design possesses many flaws that encourages water wastage and should therefore be modified. Hence, our team has come up with a product that will overcome these flaws.

As a summary of our progress and findings, we have discovered that our product has a good future on the market as it ticks the primary checkboxes on potential customers' priority list. In the long run, *TripleTap* can reduce water consumption in many areas, from private households to public restrooms.

As for our next course of action, we will begin fabrication of the prototype, and allocate time to make amendments where necessary. Fabrication will be primarily focused on ease of portability and low cost. We are confident that we will be able to deliver this product on the market.

8.0 REFERENCES

Brothers, B. (2019). How Much Water Does A Leaky Faucet Waste? Retrieved from https://bouldenbrothers.com/much-water-leaky-faucet-waste/

Nations, U. (n.d.). Goal 6: Ensure access to water and sanitation for all. Retrieved from Water and Sanitation - United Nations Sustainable Development: https://www.un.org/sustainabledevelopment/water-and-sanitation/

Reig, P., Maddocks, A., & Gassert, F. (12 December, 2013). World's 36 Most Water-Stressed Countries. Retrieved from World Resources Institute: https://www.wri.org/blog/2013/12/world-s-36-most-water-stressed-countries

Bramfit, J., Burnett, S.-A., & Ainsworth, P. (1997). A comparative study of water usage in metered and unmetered households. Journal of Consumer Studies and Home Economics, 21(2), 201–213. doi: 10.1111/j.1470-6431.1997.tb00281.x

Rizaiza, O. S. A. (1991). Residential water usage: A case study of the major cities of the western region of Saudi Arabia. Water Resources Research, 27(5), 667–671. doi: 10.1029/90wr02659

Guppy, L., Anderson, K., 2017. Water Crisis Report. United Nations University Institute for Water, Environment and Health, Hamilton, Canada

Middlesex University. (n.d.). Retrieved from https://www.mdx.ac.uk/news/2014/05/1-in-3-leave-the-tap-running-while-brushing-wasting-24-litres-of-water-a-day-finds-new-poll.

Pub. (n.d.). At Home. Retrieved from https://www.pub.gov.sg/savewater/athome.

Analogous Research | Design Methods for Education Policy. (2019). Retrieved 11 October 2019, from https://designforedpolicy.org/analogous-research

Germs in your Bathroom - SafeHome.org. (2019). Retrieved 11 October 2019, from https://www.safehome.org/resources/germs-in-your-bathroom/

Germs in Public Restrooms - SeniorLiving.org. (2019). Retrieved 11 October 2019, from https://www.seniorliving.org/research/restroom-germs/