Moskillto

Hwa Chong Institution

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1A Problem Finding

Our team started the project by brainstorming for problems using different approaches such as thematic, survey and general brainstorming. Below is a documentation of the 20 problems we have come up with as we observed the needs of the environment and society at large and how best we can solve the problem with an intended invention.(Refer to Annex A for full documentation showing clearly how our group came up with the 20 problems and their proposed inventions)

The list of 20 problems we have identified are as below:

1) Environmental Pollution
2) Visual Handicap
3) Dripping Ice-cream cone
4) Tired of Changing between using Pen and Pencil
5) Garden Maintenance
6) Laundry Drying at HDB flats
7) Too many Emails, Too Many Dates!
8) The Mosquito Issue
9) Difficult to carry and collect worksheets
10) Difficult to carry heavy bags up the stairs
11) Difficult to clean the whiteboard
12) Test tubes keep breaking
13) Global Warming
14) Keeping Cool during Hot Day
15) Lifespan of battery
16) Difficult to remember Phone Password if keep using fingerprint
17) Difficulty in locating your belongings
18) Troublesome to pour water from a jug at home
19) Carrying Hot and Cold Beverage at the Same time
20) Hard to start a conversation

1B Problem Identification

We have selected ONE problem to solve based on the following considerations:

1) Amount of existing solutions

   If there are too many existing solutions to a current problem, it will be difficult to invent a new one.

2) Feasibility

   Since we only have 9 months, we have to find a problem that is both realistic and doable in this short amount of time so as to be able to finish the whole project.

3) Significance

   We have to solve a problem that is of importance so as to be able to impact people's lives.

4) Knowledge of problem

   We need to have knowledge of the problem we are solving, otherwise we will not know what we're solving and will not know how to design a product that can solve it.

5) Availability of resources

   If the resources we want are not available, we will not be able to understand the problem, develop, test and produce the prototype.

We have used a Decision Matrix to help us through the process of scaling down from 3 problems to derive the selected problem (Refer to Annex B for the Decision Matrix). Based on the total scores for each problem, our group has identified the mosquitoes problem to be the one we would like to solve since it scores the highest and we have named our project as "**Moskillto**".

2 Problem Definition

Being in a tropical country, Singapore has been fighting mosquito infestation and mosquito borne diseases such as malaria and dengue fever since its beginning. The situation is made worse due to increasing temperature from global warming issues and the spread of imported new mosquito borne diseases such as Zika from South America. (Refer to Annex C for a chart that highlights the significance of addressing this problem)

Negative effects:

- Malaria and Dengue Fever affect the young and old to a greater extent.
- Can cause diseases such as Zika virus and dengue fever
- Allergic reactions
- Infection of wound
- Death in severe cases

The main preventive control strategies that pur NEA has taken are as follows:

1. 4 step mozzie wipeout
2. Newer methods such as wabash method
3. Mosquito traps such as Gravitrap

3 Our Idea and Concept

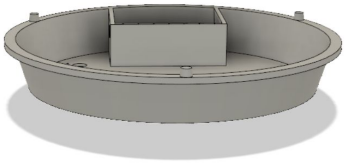
Our ideation of the concept centers around the fact that we need to have 2 separate water containers: One container is to function as the stagnant water trap that will attract mosquitoes to lay eggs in. This trap is open to the atmosphere so that mosquitoes can easily access the trap. It is not intended to trap and kill the adult mosquitoes unlike some of the current solutions available, which use a sticky tape to trap and kill the adult mosquitoes as they are laying eggs. Instead of killing the mosquitoes directly, we aim at killing the source (i.e. the eggs/larvae). This water from this channel will be kept stagnant for a fixed time period and this has to be less than the life cycle growth time from mosquito larvae to the beginning of the adult stage. After this fixed time, the water will be channeled through a microscopic filter, where larvae and pupae will be trapped and subsequently killed by dehydration, back into a sealed water reservoir. The second container is to function as a water reservoir which stores water to refill the water trap for the next cycle. This water reservoir should be large enough to hold water for a few cycles so that the device is relatively maintenance free compared to low tech solutions. This is a significant advantage as it would take a lot of manpower to periodically destroy larvae/pupae and change ovitrap water in low tech devices that are deployed in large numbers. As such, we require 2 water containers: The first being an open, black trap container that will entice mosquitoes to lay eggs in and the second being a sealed, transparent container that will hold a reservoir of water and also hold the recycled trap water (which contains valuable mosquito attractors such as pheromones). The transparent container will also allow algae to grow. This is another attractor as it is a food source for mosquito larvae.

The novelty of this invention is that it is a smart device and can be automated. We want to develop an automated system so that much less manpower and effort is needed to maintain the system. The system requires a water pump system to pump water from the trap to a filter and then to the reservoir so that larvae can collect on the filter paper and die out. A second

pump system will fill the trap with water from the reservoir. An electronic circuit is used to operate the pumps and display LEDs as indicators. An embedded computer will automate the pump operation based on time intervals and also enable images captured with a camera to be relayed wirelessly back to NEA.

Finally, we want to add a camera module to the system so that we can send pictures of the filter wirelessly back to NEA so that mosquito type and density can be analyzed.

Our solution - Features

Gravitrap	**Our Solution**
 ❖ Only 1 water container ❖ Simple solution that traps mosquitoes as they lay eggs and also traps hatched mosquitoes	 ❖ 2 water containers where 1 acts as an ideal trap environment for mosquitoes to lay their eggs and another is a water reservoir ❖ Smart solution incorporating electronics that will automatically filter out the larvae and fill the trap

Comparison with existing solution:
Our Solution - Pros

Gravitrap	Our Solution
❖ Low-cost and simple solution which contains few components	❖ An automated solution allows for less manpower ❖ Incorporate data collection of type and density of mosquitoes ❖ Water reservoir is transparent which will encourage growth of algae ❖ Water contains mosquito pheromones which attracts other mosquitoes to lay eggs

Our Solution - Cons

Gravitrap	Our Solution
❖ Manpower will be proportionate to the number of traps and a lot of effort is needed for analysis ❖ Unclear how effective it is unless trap is maintained every interval	❖ Requires a power outlet but our solution is meant to be a more permanent installation

Existing solutions:

Well-established mosquito control methods in SIngapore include the following methods:

- Expensive to maintain
- Low-Tech solution
- High maintenance and extensive use of manpower
- Not effective in killing mosquitoes

However, these methods may not be enough as Singapore is experiencing the highest dengue cases and the number of dengue clusters have proliferated over the years. As such, we initiated the Moskillto project, where we propose that a large deployment of smart mosquito water traps that automatically kills mosquito larvae and pupae after the eggs are laid in it, would be helpful in reducing the mosquito threat in Singapore.

The main benefits of our invention are as follows:

- Relatively cheap as a device but the key advantage is the manpower resources to maintain it will be much lesses compared to the gravitrap. As such, the operational expense is much lower.
- Easier to maintain as we can run through many mosquito cycles before the water reservoir becomes empty due to evaporation.
- The water in our trap becomes more and more attractive to mosquitoes as it accumulates mosquito pheromones from many cycles and also contain algae as a food source for mosquito larvae.
- Smart device with automation and we can easily capture pictures of the filter showing the type and number of mosquito larvae/pupae killed so that we can generate statistics of the mosquito population in the geolocation.
- Solves source of problem (mosquito eggs) so that we kill large potential numbers of mosquitoes rather than target single adult mosquitoes.

In contrast, the existing gravitrap solution that NEA uses has the following disadvantages compared to Moskillto:

- Although the gravitrap is a very simple device which basically has a water trap and uses a net to prevent adult mosquitoes from leaving the trap after the growth cycle, it requires a lot of manpower resources to refill the trap and also remove the debris from the container from time to time. In essence, the capital outlay to install such traps is low initially but the continuous operational expense will be large in the long run.
- We think that unless routine maintenance is done on the gravitrap, it will not be attractive for mosquitoes to select this as a breeding ground.
- No automated data collection and analysis is possible with the gravitrap.

4 Modelling and Construction Process

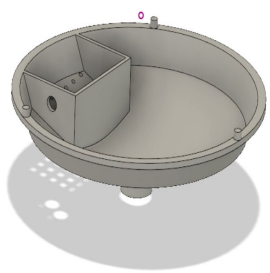
Prototype Build:

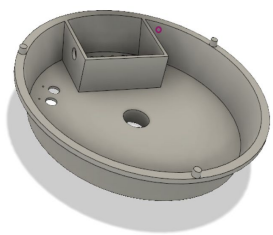
For the prototype, we have the following components

1. Water reservoir - We have used an off the shelf plastic container so that we do not need to custom make a large container.
2. Trap - We created a 3D model in fusion360 and 3D printed the part in the Physics lab. The trap was designed having the water trap compartment as well as a separate filter component and a stub for mounting one of the water pumps onto.
3. Electronic circuit - This was built using a breadboard and through hole resistor, transistor, diode and LED components. The components were wired according to the circuit and tested using 5V battery power supply.

Parts of Invention:

Trap Container





This is a black container that holds the stagnant water to entice mosquitoes to lay eggs. It also has a filter compartment that will trap and kill the larvae before they grow into adult mosquitoes.

Water Reservoir

A sealed, transparent container that will hold a reservoir of water and also hold the recycled trap water. Being transparent, it will allow algae to grow.

Water Pump

Every 8 days, the pump will pump the water through a filter and pump it back to the trap container.

Tube

Transports water from the trap container to the reservoir and back

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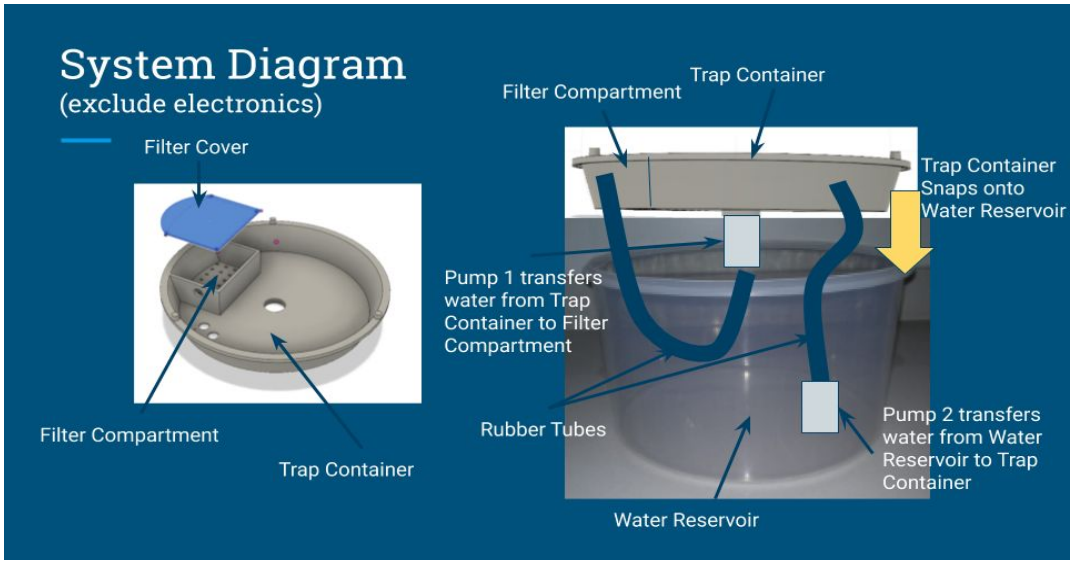
Implementation:

We have used an embedded computer called the Beaglebone so that our device has some simple built-in intelligence to automatically cycle water from trap to reservoir at a fixed period of time. When cycle 1 is completed, it will cycle water from reservoir back to trap. By enabling automatic cycling of water, we have effectively created a maintenance free trap. The components in our device are:

1. Water trap container
2. Water reservoir container
3. 2 X water pumps: 1 for channel 1 and 1 for channel 2
4. Rubber tubes to connect water trap to filter compartment and from water reservoir to water trap
5. Embedded computer called Beaglebone
6. Transistor circuit to drive the water pumps

3D Modelling:



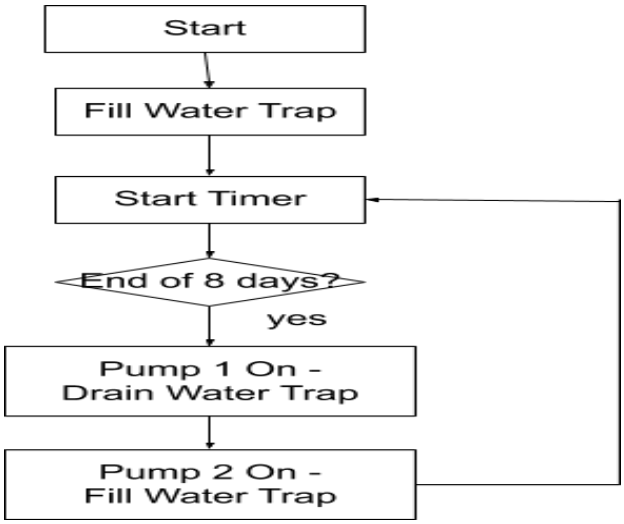
C++ program:

A C++ program has been written to control the timing and logic of our device and to output GPIO signals to control the transistors in the circuit.

Embedded computer

Our C++ Program will GPIO signals to cycle the pumps every 8 days.

Flow chart:

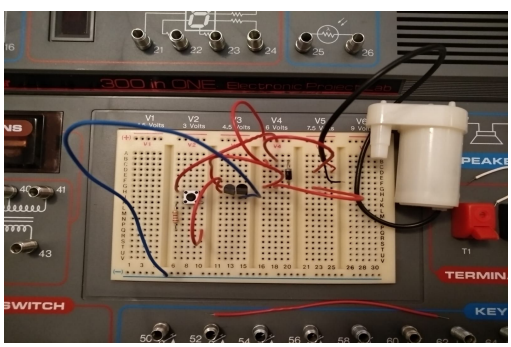


This logic will be implemented in the C++ program which will be executed on the Beaglebone computer.

Electronic circuit:

The electronic circuit contains transistors to switch the water pumps on and off. We require transistors to be used because the water pumps require around 220mA to drive the motors in the pumps. The transistors we have chosen are BC547. Since these transistors have a max current of around 100mA, we need to parallel 2 of these transistors. They will be driven by a gate current of 1mA Which comes from the GPIOs of the Beaglebone. Since we are switching motors, which have inductance, we need to also have diodes to protect the transistors from the back EMF of the motor.

Electronic circuit



Transistor circuits will turn on and off the pumps using GPIO signals from embedded computer.

Process of Construction:

Building the Prototype

Video Demonstration:
https://drive.google.com/file/d/1iKVGHUotd4TZBy9eUdo8Hax-AvE6Jrry/view

5 Evaluation and Modification

Projected Production Cost:
Estimated Bill of materials - $50
The expected cost will be lower for mass production.

(Refer to Annex D for the Table of Costs for building the Prototype)

Mock Test Results:
We have assembled the Moskillto prototype and tested the operation of the prototype. The concept works as intended. Cycle 1 was demonstrated to completely empty the trap water into the filter and back to the reservoir in 2 mins and cycle 2 refilled the trap from the reservoir in 2 mins. We added small particles to the trap to mimic the presence of mosquito larvae and pupae and our trap effectively filtered out these particles while clean water was recirculated back to the reservoir.
Summary:

- Water channels from water trap container to filter compartment and back to water reservoir as intended.
- Water refills the water trap container from the water reservoir as intended.
- The timing of the water transport works as intended showing that our C++ program logic is correct.
- We demonstrated that we are able to filter and trap small sawdust particles - millimetre and sub - millimetre size
- However, some sawdust and water still left behind at the end of the drain cycle as bottom of water trap container is flat.

Further Improvements:
Firstly we can make the bottom of the water trap container curved so that the larvae and water can be completely drained off. The reason we made this flat was the limitation due to 3D printing time and cost as many support structures will be required to build a curved 3D printed base. Our actual design uses a curved surface for the bottom of the water trap container as the final product should be manufactured using plastic injection molding where we do not have this 3D printing constraint.

Secondly, we can further improve the Moskillto by adding a USB camera to our Beaglebone and viewing the filter pad and providing either wifi or 4G connectivity. This would enable us to take images of the filter pad periodically after each water cycle to count the number of larvae/pupae collected and to possibly identify its species by using cloud computing for data analysis of the images. We think this probably can be the biggest differentiator for our system if deployed across Singapore in large numbers as it would give us a good indication of mosquito statistics rather than wait for infected patients to identify clusters, besides also acting as good mosquito control devices.

6 References

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Annex A:

Problem 1: Environmental Pollution

Environmental pollution in the form of land pollution has increasingly become an issue which is getting harder to tackle. In land scarce Singapore, the Ministry of Environment has resorted to innovative ideas of burying garbage under the assigned seabed besides incinerating garbage. Countries, such as Philippines, has allocated land as dumping ground known commonly as "garbage mountain" because the amount of trash was simply humongous. However, if people continue to be ignorant and slow to environmentally friendly and adopt the habit of recycling in their daily living, then environmental pollution will essentially become an issue in the near future which result in degradation of the quality of life.

Solution:

Taxing the people for the amount of rubbish they dispose daily into the rubbish chute. The more garbage disposed will amount to a greater amount of tax payable by them. On one hand, this will deter people from creating unnecessary garbage and cause them to be thoughtful when it comes to food wastage for instance. On the other hand, the solution encourages people to reduce, reuse and recycle. On a positive note, people can be rewarded for recycling efforts in terms of tokens of vouchers.

Proposed Invention:

Create a weighing system to be attached to base of rubbish bin / rubbish chute. Garbage is weighed before an automated opening is opened up to dump rubbish into the chute in the case of rubbish chute in a building such as HDB or condominiums. The weight of each disposal is then captured by a computer system and entered as amount taxable to be paid monthly as part of Service and Conservatory charges.

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Problem 2: Visual Handicap

The blind with no sight cannot function normally. Generally, they have difficulty moving around and appreciating the beauty of the world. What has been done is to get the visually impaired to get used to routes and routines habitually so they learn to be functional through familiarity and repetition. In this sense , their mobility is restricted unless aided and their world is still very much confined.

Solution:

To build an inclusive society, help the visually impaired perceive their surrounding by converting the images of the objects in the environment to audio interpretation and guidance for them. The camera acts as the person's eyes and the uncoded images help the user to be aware of their environment.

Proposed Invention:
Create a headset with earpiece and a customised camera making use of the synergised concepts of the satellite, GPS, steps tracker and digital convertor that will translate the images to audio prompters to guide them in the journey.

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Problem 3: Dripping Ice-cream cone
Licking ice-cream cone can be a messy affair in hot Singapore when you need to beat the heat and lick fast enough before it melts pretty quickly. The fingers get sticky and messy thereafter

Solution:
Insert a circular flap made of wax paper around the cone and above the hand position to catch any drips from the ice-cream trickling down the cone.

Proposed Invention:
Use recycled cardboard with waxy surface that provides friction and reduces the fluidity of the liquid. The circular perimeter of the flap may be tweaked slightly upwards to further prevent the melted ice-cream from dripping. The centre of the circle is slitted with a cross to push the cone through.

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Problem 4: Tired of Changing between using Pen and Pencil
During school term, clearing homework and meeting dateline can be demanding. While doing mathematics graph work which requires drawing of graph in pencil and writing answers in pen, speed may be aided by a dual pen-pencil writing equipment that just requires one to flip over easily. What a hassle it is to carry two pen and pencil during an outdoor field trip or excursion when you just need to bring one and clip it on the click board. Furthermore, it is space-saving when placed in a smaller pencil case.

Solution:
A two in one Pen cum Pencil writing equipment does the magic! The idea is an adoption and further development of the dual eraser and correction pen idea.

Proposed Invention:
One elongated circular body with one half of the body containing pen filler and the other half containing pencil lead. Use the flicker concept to push out the pen or pencil end as required simply by flipping the ends around. Refills for both the pencil lead and pen nib may be replenished through the front via the cone shaped tips at the two ends.

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Problem 5: Garden Maintenance

Tired of cutting the grass when it gets long? Feeling the pinch of employing a gardener on a regular basis? The plants, the flowers and the grass are lovely but needs ongoing upkeep which can be tiring for working folks.

Solution:

We can use a grass cutting robot that will go around on the field to do the job instead of you buying a bulky lawn mower and sweating it out or using a gardener or maid.

Proposed Invention:

An extension of the prototype of the robotic household vacuum cleaner involving a sensor to activate the robotic grass cutter (RGC) once it senses the grass exceeding a particular height. A built in criss -cross shaped plastic blade like the ones used by professional grass cutter is placed on a rotator at the base which will spin to cut the grass once activated. Rollers are placed at the bottom to allow it to move around the field. It has built-in sensor to sense obstacles and move around it to continue the job. We can also explore the possibility of including a suction or vacuum to collect the grass bits.

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Problem 6: Laundry Drying at HDB flats

We expend a lot of energy to hang out the bamboo full of heavy wet clothes over the window ledge to be placed on the laundry rack provided by the HDB. This is especially difficult for senior citizens. Furthermore, it somehow affects the external facade of the flats with built in laundry extensions outside the flat.

Solution:

An automated retractable metal (aka Dr Seus' invention) that can extend outwards to support hanging of clothes using hangers on its hook.

Proposed Invention:

The laundry bar is placed lengthwise along the external wall outside the kitchen window. Using hangers, hang the clothes and place the hangers on the circular hooks that can click to close up the hook so the hangers of clothes do not get blown off by strong wind. Depress a button briefly to extend metal bar slightly to allow hanging of more hangers. Then, we depress and hold button to extend the zigged zagged metal bar fully outwards. Once clothes are dried and collected, press another button to withdraw the laundry bar.

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Problem 7: Too many Emails, Too Many Dates!

Very often we receive plenty of email in a day with many demands and tasks needing our attention. We can be so swarmed with many datelines.

Solution:

A computer application to login the dates, events, venue and necessary actions and plot them on a monthly, weekly and daily calendar would be helpful in organising and planning.

Proposed Invention:

A programmed application to sort, categorize dates and tag meaningful data or information with it and produce a calendar of activities at a glance.

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Problem 8: The Mosquitoes Issue

Malaria and Dengue Fever affect the young and old to a greater extent.

Solution:

To reduce the presence of dengue mosquitoes and infected Anopheles mosquito.

Proposed Invention:

Have a more effective anti-mosquitoes trap

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Problem 9: Difficult to carry and collect worksheets

Monitor and subject reps take some time to sort out the worksheets according to index numbers.

Solution:

A container that allows sorting and tidy collection.

Proposed Invention:

A casing with numerous slots according to index numbers for students to place their returned worksheets

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Problem 10: Difficult to clean the whiteboard

It gets messy with all the marker dust. The top part of the board is harder to erase if one is not as tall.

Solution:

A fast and complete way to erase the whiteboard by sliding an eraser strip across the entire board from left to right without dirtying your hands.

Proposed Invention:

An automated lightweight strip with eraser placed breadth wise at one end of the whiteboard. Have an allowance border at the base to facilitate movement of the strip. Press a button to activate movenentvor manually slide the erasong strip across.

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Problem 11: Difficult to carry heavy bag up the stairs

Students carry many textbooks in their school bags and their classrooms maybe on a higher floor and they can only climb the stairs. In the long run, it may hurt the children's back causing spinal problems.

Solution:

Have some sort of support around the waist to lift off the weight of the bag off the children's shoulders and back. Place some cushion support at base of stairway for students to use if they need to on heavy bag days.

Proposed Invention:

Based on the baby cum toddler support carrying cushion, strap and buckled a lightweight but sturdy cushion around the waist and place the bag above the cushion. The load is lifted off from the body.

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Problem 12: Test tubes keep breaking

It is hard to transport your test tubes to the school laboratory without the risk of breaking them.

Solution:

Based on the concept of the test tube holder used in science laboratory, we can create a test tube holder casing to keep the test tubes fully upright and each separated from the other to avoid collision between the tubes.

Proposed Invention:

A casing with 10 holes some distance apart to hold up the test tubes. In order to be environmentally friendly, use stronger recycled cardboard material.

Problem 13: Global Warming

Due to the increased concentration of greenhouse gases brought about by factory, vehicles, there is an increase in temperature and the earth is becoming hotter.

Solution:

Cooling measures

Proposed Invention:

Invent a machine that absorbs the heat energy in the form of solar panels; Cover the top of building with reflexive surfaces; Make an air purifier that specialises in removing carbon dioxide

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Problem 14: Keeping Cool during Hot Day

Singapore is a hot and humid country all year round. We need to have a more conducive environment for learning and working in order to increase productivity and efficiency.

Solution:

Convert water vapour from the air, then convert to mist and using a mini fan to blow towards the user.

Proposed Invention:

Portable Mini Condenser releasing cooling mist

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Problem 15: Lifespan of Battery

The technological dependent millennials tend to experience frustration when they cannot surf the internet if their devices run out of battery and they forget to bring their charger.

Solution: A more efficient battery system

Proposed Invention:

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Problem 16: Difficult to remember Phone Password if keep using fingerprint

Solution: Password prompters

Proposed Invention:

Problem 17: Difficulty in locating your belongings

Solution: Attached sensor to prized items
Proposed Invention:

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Problem 18: Troublesome to pour water from jug at home

Solution: An inverted cup that can fit the mouth of the jug
Proposed Invention:

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Problem 19: Carrying Hot and Cold Beverage at the Same time

Solution: Two in One Container
Proposed Invention:

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Problem 20: Hard to start a Conversation!

Solution: Conversation Prompters
Proposed Invention:

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Annex B:

Below is the Decision Matrix we used to derive the selected problem:

Considerations for Selection	*Problems*		
	#1 Environmental Pollution	#2 Visual Handicap	#3 Mosquitoes
Consideration 1 Amount of existing solutions	3	1	2
Consideration 2 Feasibility	1	2	3
Consideration 3 Significance	3	2	1
Consideration 4 Knowledge of problem	2	1	3
Consideration 5 Availability of resources	2	1	3
Total score	11	6	12

Annex C:

Singapore Dengue Cases 3 year HIGH

18 Jun 2019 11:47PM
(Updated: 11 Jul 2019 03:59PM)

666 dengue cases recorded in Singapore last week, a 3-year high: NEA

Singapore

Weekly dengue cases in Singapore spike to highest in more than 3 years

SINGAPORE

As of Thursday, there were 188 active dengue clusters in Singapore, of which more than 45 are listed as high-risk. There have also been 7,808 dengue cases so far this year, about five times more than the same period last year.

Five people have died from dengue this year.

WARMER TEMPERATURES, MORE MOSQUITOES

A threefold increase in the Aedes aegypti mosquito population since 2013, hot weather and low herd immunity are the main reasons for the spike in cases this year, experts said.

Annex D:

ITEM	**DESCRIPTION**	**Quantity**	**PRICE**	**COST**
Water Pump	To pump water	2	$6	$12
Computer Board	Brain of Device	1	$25	$25
Plastic Containers		2	$5	$10
Transistor Circuit		2	$1	$2
Rubber Tube	Water transport	N.A.	N.A.	Around 5 cents

Total: Around $49.05